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AND

PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES

FOR

1910.

(INCORPORATED 1881.)

VOL. XLIV.

EDITED BY

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THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE STATEMENTS MADE AND THE OPINIONS EXPRESSED THEREIN.

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1910.

NOTICE.

THE ROYAL SOCIETY of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty Queen Victoria, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is 4¼ in. × 6¾ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

CORRIGENDA.

Page 95, line 23, for "unarmed," read "armed."

Page 96, line 6, for "*Notophox*," read "*Notophoyx*."

Page 109, line 4, for "*Craticus*," read "*Cracticus*."

Page 116, line 14, for "*Prosthogonimus ovatus*," read "*Prosthogonimus pellucidus*."

Page 117, insert line 20, "I have now, etc." between lines 16 and 17.

Page 121, line 16, for "*Columbia*," read "*Columba*."

Page 282, line 20, for "V-" read "U-shaped."

Page 287, last line, for "as as," read "and as."

Page 289, line 21, for "chanel," read "channel."

Page 295, line 10, read "were opposed, and negligible at others . ."
Line 12, read "stream exists—a mechanical impossibility."

Page 299, line 4, read "Now the preglacial stream either had a."

Page 301, line 10, read "Treads" are formed . . ."; line 17, read "inability."

Page 495, line 21, for "Geneal," read "General."

Page 514, line 15, insert "and" at the commencement of the line.

Page 524, line 18, for "Telai," read "Tilai."

Page 529, line 9, for "fig. 16," read "fig. 12."

Page 547, line 20, after Kiama, read "[2]"

Page 548, line 25, after "inclusion," read "from Hillgrove."

The blocks for Plates LIV., LV., LVI., illustrating the paper on "Sand Blast Tests of New South Wales Timbers," by Prof. Warren, were kindly supplied by the Government Printer.

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

Vol.	I.	Transactions of the Royal Society, N.S.W.,	1867,	pp. 83,	,,
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,, IV—	,, 291 – 425,	,,	May 4, 1910.

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,, II—	,, 161 – 273,	,,	December 12, 1910.
,, III—	,, 273 – 400,	,,	March 6, 1911.
,, IV—	,, 401 – 630,	,,	July 26, 1911.

Royal Society of New South Wales.

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FORM OF BEQUEST.

I bequeath the sum of £ to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

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Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

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Date..........................

To the
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The Royal Society of N. S. Wales,
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LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1908		Abbott, George Henry, B.A., M.B., Ch.M., 16 College-street; p.r. 'Cooringa,' 252 Liverpool Road, Summer Hill.
1877	P 5	Abbott, W. E., 'Abbotsford,' Wingen.
1895		Adams, J. H. M., Broughton Cottage, St. James' Rd., Waverley.
1904		Adams, William John, M. I. Mech. E., 175 Clarence-street.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ld., Cement Works, Granville.
1905		Anderson, Charles, M.A., D Sc. *Edin.*, Australian Museum, College-street.
1909	P 3	Andrews, E. C., B.A., Geological Surveyor, Department of Mines, Sydney.
1878		Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay.
1894	P 15	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Registrar, Sydney University.
1908	P 1	Barling, John, 'St. Adrians,' Raglan-street, Mosman.
1895	P 9	Barraclough, S. Henry, B.E., M.M.E., Assoc. M. Inst. C.E., M. I. Mech. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanical Engineering, Sydney University; p.r. 'Marmion,' Victoria-street, Lewisham.
1906		Basnett, Nathaniel James, Accountant, Punch-st., Mosman.
1894		Baxter, William Howe, Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1900		Bender, Ferdinand, Accountant and Auditor, 21 Elizabeth-street, North.
1909		Benson, William Noel, Junior Demonstrator in Geology, Sydney University, Glebe.
1905		Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street.
1905		Blakemore, George Henry, Australian Club, Macquarie-street.
1888		‡Blaxland, Walter, F.R.C.S., *Eng.*, L.R.C.P. *Lond.*, Fremantle West Australia.

Elected		
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney.
1905		Board, Peter, M.A. *Syd.*, Under Secretary and Director of Education, Department of Public Instruction, Sydney.
1907		Bogenrieder, Charles, Mining and Consulting Engineer, 'Scibile,' Little's Avenue, off Nicholson-street, Balmain.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1907		Boyd, Robert James, M.E., Assoc. M. Inst. C.E., 'Greenstead,' Park Road, Burwood.
1910		Bradley, Clement Henry Burton, M.B., Ch. M., D.P.H., Bureau of Microbiology, Macquarie-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 3 Lyons Terrace, Hyde Park.
1891		Brennand, Henry J. W., B.A., M.B., Ch. M., *Syd.*, F.R.A.S., F.G.S., 'Wabun,' 310 Miller-street North Sydney.
1902		Brereton, Victor Le Gay, Solicitor, Royal Chambers, Hunter-street; p.r. 'Osgathorpe,' Gladesville.
1878		‡Brooks, Joseph, F R.A.S., F.R.G.S., 'Hope Bank,' Nelson-street Woollahra.
1876		Brown, Henry Joseph, Solicitor, Newcastle.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Kingston,' Merrylands
1903		Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street.
1898		‡Burfitt, W. Fitzmaurice, B.A., B Sc., M.B., Ch.M., *Syd.*, 357 Glebe Road, Glebe Point.
1890		Burne, Dr. Alfred, Dentist, 1 Lyons Terrace, Liverpool-street.
1907		Burrows, Thomas Edward, M. Inst. C.E., L.S., Metropolitan Engineer, Public Works Department; p.r. 'Balboa,' Fern-street, Randwick.
1880		Bush, Thomas James, M. Inst. C.E.. Australian Gas-light Company, 153 Kent-street.
1909		Calvert, Thomas Copley, M. Inst. C.E., 'Maybank,' Manly.
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1907		Campbell, Alfred W., Medical Practitioner, 183 Macquarie-st.
1900		Canty, M., 'Rosemont,' 13 York-street, Wynyard Square.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe
1897	P 4	Cardew, John Haydon, M. Inst C.E, L.S., 75 Pitt-street.
1901		Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, N.S.W., Department of Mines.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.*, F.F.A. *Scot.*, Australian Mutual Provident Society, 87 Pitt-st. *Hon. Treasurer.*
1909		Carne, Joseph Edmund, Assistant Government Geologist, Department of Mines, Sydney.
1903		Carslaw, H. S., M.A., D.Sc., Professor of Mathematics, Sydney University, Glebe.
1909		Chalmers, Nathaneal, M. Inst. C.E, L.S., Civil Engineer, 12 Hoskins' Buildings, Spring-street.
1909		Chapman, H. G., M.D., Demonstrator of Physiology, Sydney University, Glebe.

Elected		
1879	P 1	‡Chard, J. S., Licensed Surveyor, Addison Road, Manly.
1908		Chauleur, Paul, Officier de l'Instruction Publique, Conseiller du Commerce Extérieur de la France; Secrétaire-Trésorier de la Chambre de Commerce française, 2 Bond-street.
1909	P 7	Cleland, John Burton, M.D., Ch.M., Principal Assistant, Microbiologist, Bureau of Microbiology, 93 Macquarie-street.
1907		Cobham, Allan Blenman, 'Garthowen,' Myahgah Rd., Mosman.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. Inst. C.E., Water and Sewerage Board, North Sydney.
1904	P 2	Cooksey, Thomas, Ph.D., B.Sc. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin.*, Fuller's Road, Chatswood.
1906		Colley, David John K., Superintendent, Royal Mint, Sydney.
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1876	P 3	Darley, Cecil West, M. Inst. C.E., c/o Hector Allen, Pitt and Spring streets, Sydney.
1910		Darnell-Smith, George Percy, B.Sc., F.I.C., F.C.S., Bureau of Microbiology, Macquarie-street.
1886	P 20	David, T. W. Edgeworth, B.A., F.G.S., F.R.S., C.M.G., Professor of Geology and Physical Geography, Sydney University, Glebe. *President.*
1909		Davidson, George Frederick, Tramway Offices, Hunter-street; p.r. 223 Bridge Road, Glebe Point.
1892	P 1	Davis, Joseph, M. Inst. C.E., London.
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1877		Deck, John Feild, M.D. Univ *St. And.*, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 203 Macquarie-st.; p.r. 93 Elizabeth-st., Ashfield.
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Elected		
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1906		Epps, William, Secretary, Royal Prince Alfred Hospital, Camperdown, Sydney.
1908		Esdaile, Edward William, Optician, 54 Hunter-street.
1910		Estens, John Locke, Musical Mechanician and Antiquarian, 55 Flinders-street, Sydney.
1879	P 4	Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 'Inglewood,' Colo Vale, N.S.W.
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1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1868		Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st.
1887		Faithfull, R. L., M.D. *New York* (Coll. Phys. & Surg.) L.R.C.P., L.S A. *Lond.*, 5 Lyons Terrace.
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1910		Farrel, John, Assistant Teacher, Sydney Technological College; p.r. 55 Surry-street, Darlinghurst.
1909		Fawsitt, Charles Edward, D.Sc., Professor of Chemistry, Sydney University, Glebe.
1881		Fiaschi, Thos., M.D., M. Ch. *Pisa*, 149 Macquarie-street.
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1900		‡Flashman, James Froude, M.D. *Syd.*, Jersey Road, Burwood.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin.*, 141 Macquarie-st.
1905		Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra.
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1907		Freeman, William, Harden Gold Mine, Harden, N.S.W.
1899		French, J. Russell, General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., 'Sunnyside, Stanmore Road, Enmore.
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1879		Gerard, Francis, 'The Grange,' Monteagle, near Young.
1859		Goodlet, J. H., 'Canterbury House.' Ashfield.
1906		Gosche, Vesey Richard, Consul for Nicaragua, 1 Bulletin Place, Pitt-street, City.
1906		Gosche, W. A. Hamilton, Electrical Engineer, 1 Bulletin Place, Pitt-street, City.
1897		Gould, Senator, The Hon. Sir Albert John, 'Eynesbury,' Edgecliffe.
1907		Green, W. J., Chairman, Hetton Coal Co., Athenæum Club.
1899		Greig-Smith, R., D.Sc. *Edin.*, M.Sc. *Dun.*, Macleay Bacteriologist, Linnean Society's House, Ithaca Road, Elizabeth Bay.
1899	P 2	Gummow, Frank M., M.C.E., Corner of Bond and Pitt-streets.
1891	P 15	Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 136 George-street, Sydney. *Hon. Secretary.*

Elected		
1880	P 3	Halligan, Gerald H., F.G.S., 'Riversleigh,' Hunter's Hill.
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1909		Hammond, Walter L., Science Master, Hurlstone Agricultural Continuation School, 'Rostella,' Grosvenor Crescent, Summer Hill.
1887	P 8	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department Macquarie-street North. *Vice-President.*
1905	P 1	Harker, George, D. Sc., 35 Boulevarde, Petersham.
1881		‡Harris, John, 'Bulwarra,' Jones-street, Ultimo.
1887	P 23	‡Hargrave, Lawrence, Wunulla Road, Woollahra Point.
1884	P 1	Haswell, William Aitcheson, M.A., D. Sc., F.R.S., Professor of Zoology and Comparative Anatomy. University, Sydney; p.r. 'Mimihau,' Woollahra Point.
1900		Hawkins, W. E., Solicitor, 88 Pitt-street.
1891	P 1	Hedley, Charles, F. L. S., Assistant Curator. Australian Museum, Sydney.
1899		Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st.
1884	P 1	Henson, Joshua B., Assoc. M. Inst. C.E. Hunter Distriot Water Supply and Sewerage Board, Newcastle,
1905		Hill, John Whitmore, Architect, 'Willamere,' May's Hill, Parramatta.
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1892		Hodgson, Charles George, 157 Macquarie-street.
1901		Holt, Thomas S., 'Amalfia,' Appian Way, Burwood.
1905		Hooper, George. Assistant Superintendent, Sydney Technical College; p.r. 'Branksome,' Henson-street, Summer Hill.
1905		Hoskins, George J., M. I. Mech. E., Burwood Road, Burwood.
1891	P 2	Houghton, Thos. Harry, M. Inst. C.E., M. I. Mech. E., 63 Pitt-street.
1906		Howle, Walter Creswell, Medical Practititioner, Bega, N.S.W.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Acting Chief Inspector of Mines, Geological Surveyor, Department of Mines.
1904		Jenkins, R. J. H., 'Ettalong,' Roslyn Gardens, Rushcutters Bay.
1905	P 5	Jensen, Harold Ingemann, D.Sc., 'Kinross,' Woolwich Road, Woolwich.
1907		Johnson, T. R., M. Inst. C.E., Chief Commissioner of New South Wales Railways, Public Works Department.
1909	P 11	Johnston, Thomas Harvey, M.A., D. Sc., Assistant Government Microbiologist, Bureau of Microbiology, 93 Macquarie-st.
1902		Jones, Henry L., Assoc. Am. Soc. C.E., 14 Martin Place.
1884		‡Jones, Llewellyn Charles Russell, Solicitor, Falmouth Chambers, 117 Pitt-street.
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 'Llandilo,' Boulevard, Strathfield.
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C.E., Stephen Court, 77 Elizabeth-street; p.r. 'Moppity,' Springdale Road, Killara.

Elected		
1907		Kaleski, Robert, Agricultural Expert, Holdsworthy, Liverpool,
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1873	P 3	Keele, Thomas William, M. Inst. C.E., Commissioner, Sydney Harbour Trust, Circular Quay; p.r. Llandaff-st., Waverley.
1887		Kent, Harry C., M.A., F.R.I.B.A., Bell's Chambers, 129 Pitt-st.
1901		Kidd, Hector, M. Inst. C E, M. I. Mech. E., 'Craig Lea,' 15 Mansfield-street, Glebe Point.
1896		King, Kelso, 120 Pitt-street.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.G.S. *Irel.*, 'Wellington,' Bondi Road, Bondi.
1881	P 20	Knibbs, G. H., C.M.G., F.S.S., F.R.A.S., Member Internat. Assoc. Testing Materials; Memb, Brit. Sc. Guild; Commonwealth Statistician, Melbourne.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1909		Lawrence, Richard Priestly, M. Inst. C.E., Civil Engineer, 12 Hoskin's Buildings, Spring-street.
1906		Lee, Alfred, Merchant, 'Glen Roona,' Penkivil-st. Bondi.
1909		Leverrier, Frank, B.A., B.Sc., Barrister-at-Law, 182 Phillip-st.
1883		Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street.
1901		Little, Robert, 'The Hermitage,' Rose Bay.
1872	P 57	Liversidge, Archibald, M.A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch. Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem, of Gt. Brit. and Irel.; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phys. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France*; Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc. *Tas.*; Roy. Soc., *Queensland*; Senckenberg Institute, *Frankfurt*; Société d' Acclimat., *Mauritius*; Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy. Soc., *Vict.*; N. Z. Institnte; K. Leop. Carol. Acad., *Halle a/s*; 'Hornton Cottage,' Hornton-st., Kensington, London, S.W.
1906		Loney, Charles Augustus Luxton, M. Am. Soc, Refr, E., Equitable Building, George-street.
1884		MacCormick, Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street.
1903		McDonald, Robert, J.P., Under Secretary for Lands; p.r. 'Wairoa,' Holt-street; Double Bay.
1891		McDouall, Herbert Crichton, M.R.C S. *Eng.*, L.R.C.P *Lond.*, D.P.H. *Cantab.*, Hospital for the Insane, Gladesville.
1906		McIntosh. Arthur Marshall, Dentist, William-st, Chatswood.
1891	P 2	McKay, R, T., Assoc. M. Inst. C.E., Geelong Waterworks and Sewerage Trusts, Trusts Offices, Geelong.
1893		McKay, William J. Stewart, B.Sc., M.B., Ch.M., Cambridge-straet, Stanmore.
1876		Mackellar, The Hon. Charles Kinnaird, M.L.C. M.B., C.M. *Glas.*, Equitable Building, George-street.

Elected		
1904		McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage,' Bronte Road, Waverley.
1880	P 9	McKinney, Hugh Giffin, M.E., Roy. Univ. *Irel.*, M. Inst. C.E., Australian Club, Macquarie-street.
1903		McLaughlin, John, Solicitor, Union Bank Chambers, Hunter-st.
1876		MacLaurin, The Hon. Sir Henry Normand, M.L.C., M.A., M.D., L.R.C.S. *Edin*, LL.D. *St. Andrews*, 155 Macquarie-street.
1901	P 1	McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road,, Woollahra Point.
1894		McMillan, Sir William, K.C.M.G., 'Llandudno,' Old South Head Road, Woollahra.
1899		MacTaggart, J. N. C., M.E. *Syd.*, Assoc M. Inst. C.E. Water and Sewerage Board District Office, Lyons Road, Drummoyne.
1909	P 21	Madsen, John Percival Vissing, D.Sc., B.E., P. N. Russell Lecturer in Electrical Engineering, Sydney University.
1883		Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc., S.A.; Hon. Memb. Nat. Hist, Soc., W.A., Netherlands Soc. for Promotion of Industry; Philadelphia College Pharm.; Southern Californian Academy of Sciences; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin,; Soc. Nac. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc. Tas., Inst. Nat. Genévois; Hon. Vice-Pres. of the Forestry Society of California; Diplomé of the Société Nationale d' Acclimatation de France; Government Botanist and Director, Botanic Gardens, Sydney. *Hon. Secretary.*
1906	P 1	Maitland, Louis Duncan, Dental Surgeon, 6 Lyons' Terrace, Liverpool-street.
1880		Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, B.A., M.A., LL.B. *Melb.*, LL.D. *Syd.*, Principal, Presbyterian Ladies' College, Sydney.
1908	P 26	Marshall, Frank, B.D.S. *Syd.*, Dental Surgeon, 141 Elizabeth-st.
1875		Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d'Anthrop. de Paris, Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Anthrop. Soc., Vienna; Cor. Mem. Roy. Geog. Soc. Aust., Q'sland; Local Correspondent Roy. Anthrop. Inst., Lond.; 'Carcuron,' Hassall-st., Parramatta.
1903		Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria.
1905	P 8	Miller, James Edward, Inverell, New South Wales.
1889		Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Union Club, Sydney.
1877		‡Mullens, Josiah, F.R.G.S., 'Tenilqa,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.
1876		Myles, Charles Henry, 'Dingadee,' Everton Rd., Strathfield.

Elected		
1893	P 2	Nangle, James, Architect, 'St. Elmo,' Tupper-st., Marrickville
1891		‡Noble, Edward George, Public Works Department, Newcastle,
1893		Noyes, Edward, Assoc. Inst. C.E., Assoc. I. Mech. E., c/o Messrs. Noyes Bros., 109 Pitt-street.
1903		Old, Richard, Solicitor, 'Waverton,' Bay Rd., North Sydney.
1896		Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle.
1875		O'Reilly, W. W. J., M.D., M.Ch. Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 129 Liverpool-street, Hyde Park.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Water Supply Branch, Sydney, 'Linton,' Parkes-street, Ryde.
1883		Osborne, Ben, M., J.P., 'Hopewood,' Bowral.
1906		Oschatz, Alfred Leopold, Teacher of Languages, 46 High-st., North Sydney.
1903		Owen, Rev. Edward, B.A., All Saints' Rectory, Hunter's Hill.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 183 Liverpool-street, Hyde Park.
1906		Pawley, Charles Lewis, Dentist, 137 Regent-street,
1901		Peake, Algernon, Assoc. M. Inst. C.E., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. 'Plashett,' Jerry's Plains viâ Singleton.
1877		Pedley, Perceval R., Australian Club.
1899		Petersen, T. Tyndall, Member of Sydney Institute of Public Accountants, Copper Mines, Burraga.
1909	P 1	Pigot, Rev. Edward F., S.J., B.A., M.B. *Univ. Dub.*, St. Ignatius College, Riverview.
1879	P 7	Pittman, Edward F., Assoc. R.S.M., L.S., Under Secretary and Government Geologist, Department of Mines.
1896		Plummer, John, 'Northwood,' Lane Cove River; Box 413 G.P.O.
1881		Poate, Frederick, Lands Department, Sydney.
1879		Pockley, Thomas F. G., Union Club, Sydney.
1887	P 7	Pollock, James Arthur, D.Sc. *Syd.*, Corr. Memb. Roy. Soc., Tasmania; Roy. Soc., Queensland; Professor of Physics in the University of Sydney.
1896		Pope, Roland James, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street.
1910		Potts, Henry William, F.L.S., F.C.S., Principal, Hawkesbury Agricultural College, Richmond, N.S.W.
1893		Purser, Cecil, B.A., M.B., Ch. M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1901	P 1	Purvis, J. G. S., Water and Sewerage Board, 341 Pitt-street.
1908		Pye, Walter George, M.A., B.Sc., Nield Avenue, Paddington.
1876		Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden,' 14 Queen-street, Woollahra. *Vice-President.*

Elected		
1890	P 1	Rae, J. L. C., 75 King-street, Newcastle.
1865	P 1	‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., 8 Palace-street, Petersham.
1890		Rennie, George E., B.A. *Syd*,, M.D. *Lond.*, M.R.C.S. *Eng.*, 159 Macquarie-street.
1906		Redman, Frederick G., P and Office, Pitt-street.
1909		Rhodes, Thomas, Civil Engineer, Carlingford and Public Works Department.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1906		Richardson, H. G. V., 15 Lombard Chambers, Pitt-street City.
1892		Rossbach, William, Assoc. M. Inst. C.E., Public Works Department, Sydney.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 147 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1904	P 3	Ross, William J. Clunies. B.Sc., *Lond. & Syd.*, F.G.S., Lecturer in Chemistry, Technical College, Sydney.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club.
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., 164 Pitt-st.

1905		Scheidel, August, Ph. D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club.
1899		Schmidlin, F., 39 Phillip-street, City.
1892	P 1	Schofield, James Alexander, F C.S., A.R.S.M., University, Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1877	P 4	Selfe, Norman, M. Inst. C.E., M. I. Mech. E., Victoria Chambers, 279 George-street.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Cairnleith,' Military Road, Mosman.
1908		Sendey, Henry Franklin, Manager of the Union Bank of Australia, Ld., Sydney; Union Club.
1883	P 3	Shellshear, Walter, M. Inst. C. E., Inspecting Engineer, Existing Lines Office, Bridge-street.
1905		Simpson, D. C., M. Inst. C.E., N.S.Wales Railways, Redfern; p.r. 'Clanmarrina,' Rose Bay.
1900		Simpson, R. C., Technical College, Sydney.
1910		Simpson, William Walker, Merchant, Leichhardt-st. Waverley.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. Cleveland-street, Wahroonga,
1893		Sinclair, Russell, M. I. Mech. E., etc, Vickery's Chambers, 82 Pitt-st.
1891	P 3	Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1893	P 37	Smith, Henry G., F.C.S., Asssistant Curator, Technological Museum, Sydney.
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1892	P 1	Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta.
1900		Stewart, Professor J. D., M.R.C.V.S., University of Sydney; p.r. Cowper-street, Randwick.
1903		Stoddart, Rev. A, G., The Rectory, Manly.

Elected		
1909		Stokes, Edward Sutherland, M.B. *Syd.*, R.C.P.S. *Irel.*, Medical Officer. Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street,
1883	P 4	Stuart, T. P. Anderson, M.D., LL.D. *Edin.*, Professor of Physiology, University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay.
1901	P 3	Süssmilch, C. A., F.G.S., Technical College, Sydney.
1907		Sutherland, David Alex., F.I.C., Equitable Building, George-st,
1906		Taylor, Sir Allen, Lord Mayor of Sydney, 'Woolton,' Darley-street, Darlinghurst.
1906		Taylor, Horace, Registrar, Dental Board, 7 Richmond Terrace, Domain.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona,' 43 East Crescent-street, McMahon's Point, North Sydney.
1893		‡Taylor, James, B.Sc., A.R.S.M., 'Addarton,' Dundas.
1899		Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1878		Thomas, F. J., Newcastle and Hunter River Steamship Co., 147 Sussex-street.
1879		Thomson, Hon. Dugald, M.H.R., Carabella-st., North Sydney.
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Cantab.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street.
1896		Thompson, Capt. A. J. Onslow, Camden Park, Menangle.
1892		Thow, William, M. Inst. C.E., M. I. Mech E., 'Glen Isla,' Warrawee.
1894		Tooth, Arthur W., Kent Brewery; 26 George-street, West.
1879		Trebeck, P. C., F. R. Met. Soc., 12 O'Connell-street.
1900		Turner, Basil W., A.R.S.M., F.C.S., Victoria Chambers, 83 Pitt-st
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1890		Vicars, James, M.C.E., Master of Engineering and Architecture, Memb. Int. Ass. Testing Materials; Memb, B. S. Guild; Challis House, Martin Place.
1892	P 4	Vickery, George B., 78 Pitt-street.
1903		Vonwiller, Oscar U., B Sc. Demonstrator in Physics, University of Sydney.
1876		Voss, Höulton H., J.P., Union Club, Sydaey.
1907		Waley, F. G., Assoc. M. Inst. C.E., Royal Insurance Building, Pitt-st.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, Senator The Hon. J. T., 'Wallaroy,' Edgecliffe Road, Woollahra.
1910		Walker, Charles, Metallurgical Chemist, etc., 'Kuranda,' Waverley-street, Waverley.
1910		Walker, Harold Hutchison, Major St. Georges English Rifle Regiment, C.M.F., 'Vermont,' Belmore Road, Randwick.
1910		Walkom, Arthur Bache, B.Sc., Junior Demonstrator in Geology, Sydney University; p.r. 'Lang-hay,' Fisher-st., Petersham.

Elected		
1901		Walkom, A. J., A.M.I.E.E., Electrical Branch, G.P.O., Sydney.
1891	P 2	Walsh, Henry Deane, B A.I., T.C. *Dub.*, M. Inst C.E., Engineer-in-Chief, Harbour Trust, Circular Quay. *Vice-President.*
1903		Walsh, Fred., George and Wynyard-streets; p.r. 'Walsholme,' Centennial Park, Sydney E.
1901		Walton, R. H., F.C.S, 'Flinders,' Martin's Avenue, Bondi.
1898		Wark, William, Assoc. M. Inst. C.E., 9 Macquarie Place, p.r. Kurrajong Heights.
1883	P 17	Warren, W. H., Wh. Sc., M. Inst. C.E, M. Am. Soc. C.E., Member of Council of the International Assoc. for Testing Materials, Professor of Engineering, University of Sydney.
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman, Attorney General's Department, Macquarie-st.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville
1910		Watson, James Frederick, M.B., Ch. M., Medical Practitioner, Australian Club, Sydney.
1910		Watt, Francis Langston, F.I.C, A.R.C.S, 10 Northcote Chambers, off 16½ Pitt-street, City.
1908		Weatherburn, Charles Ernest, M.A., B. Sc., *Syd.*, B.A. *Cantab.*, Ormond College, Parkville, Melbourne.
1910		Wearne, Richard Arthur, B.A, Principal, Technical College, Ipswich, Queensland.
1897		Webb, Frederick William, C.M.G., J P., 'Livadia,' Manly.
1903		Webb, A, C. F., M.I.E.E., Vickery's Chambers, 82 Pitt-street.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L.S., *New Zealand*, Town Hall. Sydney.
1907		Weedon, Stephen Henry, C.E., 'Kurrowah,' Alexandra-street, Hunter's Hill.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, C.M.G., Head Master, Sydney Grammar School, College-street.
1907		Welch, William, F.R.G.S., 'Roto-iti,' Boyle-street, Mosman.
1881		‡Wesley, W. H.
1892		White, Harold Bogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1909		White, Charles Josiah, Science Lecturer, Sydney Training College; p.r. 'Patea,' Miller Avenue; Ashfield,
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Sellinge,' Albert-st., Woollahra.
1907		Wiley, William, 'Kenyon,' Kurraba Point, Neutral Bay.
1876		Williams, Percy Edward, 'Drumart,' Wentworth Falls.
1908		Willis, Charles Savill, M.B., Ch. M *Syd.*, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H., Roy. Coll. P. & S. *Lond.*, Department of Public Health.
1901		Willmot, Thomas, J.P., Toongabbie.
1890		Wilson, James T., M.B., Ch. M. *Edin*, Professor of Anatomy, University of Sydney,
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1909		Woodhouse, William John, M.A., Professor of Greek, Sydney University, Glebe.
1906	P 4	Woolnough, Walter George D. Sc., F.G.S., Demonstrator in Geology, University of Sydney.
1909		Yeomans, Richard John, Solicitor, 14 Castlereagh-street.

Elected		HONORARY MEMBERS. *Limited to Thirty.* M.—Recipients of the Clarke Medal.
1875		Bernays, Lewis A., C.M.G., F.L.S., Brisbane.
1900		Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W.
1905		Fischer, Emil, Professor of Chemistry, University, Berlin.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew.
1901		Judd, J.W., C.B., LL.D., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London; 30 Cumberland Road, Kew, England.
1908		Kennedy, Sir Alex. B. W., LL.D., F.R.S., 17 Victoria-street, Westminster, London S.W.
1903		Lister, Right Hon. Joseph, Lord, O.M., B.A., M.B., F.R.C.S. D.C.L., F.R S., Hon. M. Inst. C.E., etc., 12 Park Crescent, Portland Place, London, W.
1908		Liversidge, Prof., M.A., LL.D., F.R.S., 'Hornton Cottage,' Hornton-street, Kensington, London S.W.
1905		Oliver, Daniel, LL.D., F.R S., Emeritus Professor of Botany, University College, London.
1894		Spencer, W. Baldwin, M.A., C.M.G, F R.S., Professor of Biology, University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., LL.D., Sc. D., Ph. D., The Ferns, Witcombe, Gloucester, England.
1908		Turner, Sir William, K.C.B., M.B., D.C.L., LL.D., Sc. D., F.R.C.S. *Edin.*, F.R.S., 6 Eton Terrace, Edinburgh, Scotland.
1895	.	Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Old Orchard, Broadstone, Wimborne, Dorset.

		OBITUARY 1910. *Honorary Members.*
1905		Prof. Cannizzaro, Stanislao.
1892		Huggins, Sir William.
		Ordinary Members.
1896		Spencer, Walter, M.D.
1868		MacDonnell, W. J.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

THE LATE REVD. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia. The prefix * indicates the decease of the recipient.

1878 *Professor Sir Richard Owen. K.C.B., F.R.S.

1879 *George Bentham, C.M.G., F.R.S.

Elected

1880 *Professor Thos. Huxley, F.R.S., The Royal School of Mines, London.

1881 *Professor F. M'Coy, F.R.S., F.G.S.

1882 *Professor James Dwight Dana, LL.D.

1883 *Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S.

1884 *Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S.

1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.

1886 *Professor L. G. De Koninck, M.D., University of Liège.

1887 *Sir James Hector, K.C.M.G., M.D., F.R.S.

1888 *Rev. Julian E. Tenison-Woods, F.G.S., F.L.S.

1889 *Robert Lewis John Ellery, F.R.S., F.R.A.S.

1890 *George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S.

1891 *Captain Frederick Wollaston Hutton, F.R.S., F.G.S.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., late Director, Royal Gardens, Kew.

1893 *Professor Ralph Tate, F.L.S., F.G.S.

1895 Robert Logan Jack, F.G.S., F.R.G.S., late Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.

1896 *Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S.

1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.

1901 *Edward John Eyre.

1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.

1903 *Alfred William Howitt, D. Sc. *Cantab.*, F.G.S., Hon. Fellow Anthropol. Inst. of Gt. Brit. and Irel.

1907 Walter Howchin, F.G.S., University of Adelaide.

1909 Dr. Walter E. Roth, B.A., Pomeroon River, British Guiana, South America.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper on 'The Tin deposits of New South Wales.

1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, B.Sc., M.B. *Lond*, F.R.S., Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By H. D. WALSH, B.A.I., T.C. *Dub.*, M. Inst. C.E.

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IT has been the common practice on these occasions for the President to take as his subject the particular branch of Science in which he is actively engaged in the prosecution of his professional duties, and, following on these lines, I propose this evening to say a few words in connection with the very important subject of transport. Mr. Thomas Telford, the first President of the Institution of Civil Engineers, when applying for a Charter in 1828, defined an engineer as one "who directs the great sources of power in nature for the use and convenience of man," and certainly in no way has the engineer justified that definition of his calling more fully than in the skill and energy shown in providing for the transport of passengers and merchandise to almost every known place on the earth's surface. Transport includes many branches of engineering, harbours, breakwaters and docks for the protection and accommodation of vessels engaged in transport by sea; railways, with their tunnels, viaducts and other important and costly works, for rapid conveyance by land; and lastly, but by no means of less importance, roads which provide means of communication for the conveyance of goods and passengers to even the most remote parts of the country. Then we have other great groups of engineers in the shipbuilders; the locomotive constructors; the electrical engineers; the motor car builders; and may I add the designers and constructors of aeroplanes and other flying machines, all working with the one object of providing efficient means of transport by water, land and air. Few people, I think,

realize the vast improvements that have been made in this direction of recent years, and it may be interesting to compare the easy and rapid means of communication enjoyed at the present time with those of a comparatively few years ago.

Some interesting articles have lately appeared in one of the American magazines on the subject of the invention of the steamboat, and the honour of having constructed the first steamboat of any commercial value is claimed for Robert Fulton, an energetic American, who in 1807 built and successfully navigated a steamboat on the Hudson River. So far as I can ascertain from the records at my disposal, a Mr. Miller, as far back as 1788, made some successful experiments in Scotland with a twin boat fitted with a small engine made by William Symington and propelled by a paddle wheel placed in the space between the twin boats; with this a speed of three miles an hour was obtained. Some few years later Mr. Symington constructed a steamer for the purpose of towing barges on the Forth and Clyde Canal. This vessel, which was named the "Charlotte Dundas," had a small engine with one horizontal cylinder twenty-two inches in diameter and four feet stroke, with connecting rod and crank which worked a single paddle wheel placed in a well-hole at the stern of the vessel. The vessel proved a success, but as the proprietors of the canal objected to the use of the paddle wheel, the wash of which they alleged would injure the banks, she was abandoned in 1802. For some years previous to this numerous attempts had been made in England, Scotland, America and France to utilize steam as a motive power for boats. Among the many experimenters were Messrs. Robert Fulton and Robert Livingstone, who commenced their experiments with a steamboat on the Seine in 1802, but the weight of the engine broke the vessel in two and

the boat was precipitated to the bottom. Fulton subsequently visited Scotland and it is said, was taken for a trip in the "Charlotte Dundas,". and with the knowledge thus gained he returned to America to further prosecute his experiments. In August 1803, Fulton wrote to Boulton and Watt to order a steam engine for a boat to be launched in America, and he evidently anticipated the great difficulty he subsequently experienced in persuading the authorities to allow the engine to be sent to America from England. With our modern ideas of detailed specifications Fulton's order for this engine seems to be simplicity itself. It was as follows:—"If there is not a law which prohibits the exportation of steam engines to the United States of America, or if you can obtain a permit to export parts of an engine, will you be so good as to make me a cylinder of twenty-four horse power, double effect, the piston rod making a four foot stroke; also the piston and piston rod. The valves and movements for opening and shutting them, the air pumps and rod, the condenser with its communications to the cylinder and air pumps etc." It was only after much correspondence and many interviews with the authorities in England, that a permit was granted to export this engine from England, which on arrival was placed in the vessel constructed to receive it. Fulton's own description of the "Clermont" is as follows:—"My first steamboat on the Hudson River was 150 feet long, 13 feet wide, drawing 2 feet of water bow and stern 60°; she displaced 3,640 cubic feet, equal 100 tons of water; her bow presented 26 feet to the water plus and minus the resistance on one foot running four miles an hour." On the 17th August. 1807, the "Clermont" made her first voyage on the Hudson River and shortly afterwards became a regular trader between New York and Albany, a distance of 150 miles, doing the trip in from 30 to 36 hours. It will thus be seen that, although Symington's steamer, the

"Charlotte Dundas," was successfully employed towing barges in 1802, Fulton's "Clermont" was the first steamer employed for regular passenger traffic in 1807, for it was not till 1812 that the first regular steam passenger boat made its appearance on the Clyde, the "Comet" in that year running regularly between Glasgow and Greenock at a speed of five miles an hour. The "Comet" was 42 feet long and 11 feet beam with a four horse power engine, placed on one side of the boat and a small wrought iron boiler on the other side.

In 1819 the "Savannah" crossed the Atlantic; this vessel was 380 tons and had been built as a sailing ship, but was fitted with auxiliary steam power, the paddle-wheels being designed so that they could be unshipped when the vessel was under sail. Under steam she obtained a speed of six knots, but the engines were only used on 18 days during the trip of 35 days, and after this voyage the the engines and boiler were removed. The first iron paddle steamer, the "Aaron Manby," crossed the English Channel in 1821. The "Sirius," which left London on the 4th of April, 1838, arrived at New York on 22nd, after a voyage of seventeen days, and was the first steamer to cross the Atlantic from Great Britain, obtaining this distinction only by a few days, for the "Great Western" a wooden steamer of 212 feet long, 38½ feet beam and 23½ feet deep, built under the advice of Mr. J. K. Brunel, left Bristol 8th April and arrived at New York only a few hours after the "Sirius."

In 1852 the P. and O. Company undertook the first regular mail service to Australia, running once every two months viâ Singapore; in 1864 the service was increased to one sailing a month, and in 1874 arrangements were made by which the mails were to be carried through the Suez Canal which had been opened for traffic a few years

previously, viz., in 1865. Gradual improvements were made from time to time in our mail services, but as late as 1877 the passage from Southampton to Sydney was still long and tedious. Thirty-three years ago I left England for Australia in the P. and O. Company's s.s. "Poonah," a vessel of 3,130 tons, then engaged in the Indian mail service. At Point de Galle the Australian mails and passengers were transhipped into the s.s. "Tanjore," a vessel 2,263 tons; on arrival at Melbourne we were again transferred to another of the company's steamers, the "Avoca," a poorly equipped little craft, more suitable for a collier than a passenger boat, finally reaching Sydney after a passage of fifty-two days. In 1877 the Orient Company's steamer "Lusitania" paid her first visit to Sydney and was followed by the "Chimborazo" and the "Cuzco," vessels of 3,847 to 3,883 tons, making the trip from England viâ the Cape in fifty-three days, and returning viâ the Suez Canal. How incomparably superior are these Companies' mailboats of to-day, steamers of from 11,000 to 12,500 tons, equipped with every modern appliance for the handling of cargo and the comfort of the passengers leaving and arriving at their terminal ports each week with clockwork regularity, and completing their trips in less than forty days, plying to and fro like the shuttle in the loom, weaving the thread of commerce from Great Britain to Australia and back from our island continent to the Mother Land.

The record of speed and of size is at present held by those splendid Cunarders the "Lusitania" and the "Mauretania" engaged in the Atlantic trade. These vessels are 790 feet long with a registered tonnage of 32,500 tons. They are fitted up with all the luxury and comfort of an up-to-date hotel, and equipped with every modern appliance that skill and science could devise. On her contract trials the "Mauretania" maintained an

average speed of 26·04 knots for a distance of a little over 1,200 knots, the steaming time being rather less than forty-eight hours, and on at least two occasions she has exceeded this speed on her ordinary trips across the Atlantic. The regularity of speed maintained by the "Mauretania" on a long sequence of consecutive passages is truly remarkable. In February of last year, in fourteen trans-Atlantic passages to and fro, made of course under varied weather conditions, some of them against strong winds and high seas, the average speed for the fifteen trips, approaching 45,000 sea miles in length, was 25½ knots. The trips made by the "Lusitania" are run with similar regularity.

Even these ships are shortly to be eclipsed by the two White Star leviathans now being built by Messrs. Harland and Wolff, in Belfast. The "Olympic" and the "Tita[illegible]" will be 860 feet long with a registered tonnage of [illegible],000 tons and a displacement of 60,000 tons, they will be run by a combination of turbine and reciprocating engines and are expected to develop a speed of twenty-two knots, crossing the Atlantic in seven days. The carrying capacity of these great liners will exceed that of any vessel now afloat by at least one-third, and the scientific appliances for use in case of collision or fire are most complete. The opening and closing of the doors in the bulkheads is controlled from the bridge, and by a series of thermostats fixed throughout the framework, the officer on the bridge is at once made aware of an outbreak of fire in any part of the ship. Some idea of the dimensions and weight of these vessels may be formed from the fact that the weight of the stern frame castings alone is over seventy tons, and the shaft brackets supporting the after propellers' weight about seventy-five tons, while the upper part of the stern-frame is 63 feet high and 22 feet wide.

In 1828 the British Empire owned 293 steamers aggregating 32,000 tons, and during that year 31 steamers of

less than 2,300 tons were added to the register. Last year there were 22,522 steamers entered in Lloyds' register, and during 1909, exclusive of war ships, 465 steamers of 972,799 tons were launched in the United Kingdom. Practically the whole of the tonnage launched was built of steel.

The vital problem for the future of ocean transport, as indeed of all forms of transport, is that of economy of the motive power. The most efficient types of steam engines now used for marine work only realise in the propeller shaft from 10 to 11% of the total heat value of the coal consumed. A consumption of coal equal to 1 lb. per indicated horse power per hour can be obtained with reciprocating engines, but only under the best conditions. Under usual service a consumption of $1\frac{1}{2}$ lbs. per horse power is considered a very good performance even with turbine engines, but in point of fact 2 lbs. is much nearer the mark in general practice.

Experience on shore with producer gas engines has shown that this type of prime mover is capable of developing a brake horse power on a consumption of 1 lb. of coal or less per hour, while about 17% of the heat value of the fuel consumed is turned into useful work at the engine shaft, or nearly twice as much as can be obtained from the reciprocating steam engine, and about one and a half times that which is yielded by the steam turbine. The sum of the two principal losses in the steam plant, namely, the funnel and the condenser losses, is nearly equal to the sum of the two most important losses in the gas plant—the water jacket and exhaust losses. But whereas there is little chance of utilising the heat thus lost in the steam plant, there is promise of utilising at least a portion of that lost in a gas plant.

It seems inevitable that a system of generating power which both theoretically and practically offers such a

marked economy in fuel consumption will in the end survive the steam power plant.

The type of producer plant used on land is manifestly not suited for marine work, as it weighs as a rule over 200 lbs. per brake horse power, but producer plants designed especially for marine work can be built weighing from 75 to 90 lbs. and occupying a floor space of $\frac{1}{4}$ to $\frac{1}{3}$ of a square foot per B.H.P. It is therefore evident that the marine gas producer has a decided advantage both in weight and space occupied per B.H.P. over the steam plant, which for passenger and cargo service weighs a trifle under 200 lbs. and occupied about $\frac{1}{3}$ square foot per B.H.P.

The importance to Australian trade of the development of the marine producer gas plant can hardly be overestimated. There are at present several vital difficulties that have to be overcome before the suction gas plant can be made as flexible as the steam plant. These, however, are being seriously grappled with and everything points to the fact that this form of obtaining energy is rapidly coming to the front. A large vessel has lately been built and equipped with such plant in the United States, but particulars as to her effectiveness have not yet come to hand. Locally a lighter was recently built and equipped with a producer gas plant.

Coming next to the question of Harbours and Wharfage for the protection and accommodation of this ever-increasing volume of shipping, it is interesting to note the progress that is being made in this direction. All over the world the evolution of shipping, which shows as yet no signs of working itself out, is causing great activity in marine engineering; indeed it is scarcely too much to say that for many reasons it is difficult, if not impossible, for harbour works to keep even pace with the increasing requirements of over-sea shipping. What was a few years ago sufficient

in accommodation, strength and draft of water, is to-day inadequate. As far as this country is concerned, even at the leading ports of each State, a considerable portion of the wharfage which a few years ago was ample for the trade is now becoming obsolete, and though every effort is being made to keep pace with shipping requirements, the difficulties that inevitably arise and delays that cannot be obviated, make progress appear slow.

What the present local wharfage requirements are, and are likely to become in the future, can best be gauged by a comparison between the ships of to-day and those of forty years ago, to accommodate which most of our harbours were designed. In the seventies the over-sea Australian trade was carried almost entirely in sailing ships of 800 to 1,500 tons. These ranged in lengths from 180 to 270 feet, the draft of water being from 20 to 24 feet. Even so late as the eighties very few in any part of the world foresaw the enormous and rapid increase that was destined to take place in size and draft. Vessels now trading to Australian ports very nearly touch the 14,000 ton mark. Many are upwards of 500 feet in length and require in some instances 32 feet of water to berth.

Judging by the past there can be but little doubt that vessels will at no distant period reach a length of 1,000 feet and a draft of from 35 to 38 feet, and harbour engineers must be prepared to provide adequate accommodation for them. At the present time a vessel of 38 feet draft could be accommodated in only a comparatively few harbours in the world. From available returns I find that there are only sixteen ports that can boast of approach channels of 35 feet and upwards, at the present time, but in many cases the work of providing deeper water is in progress. For this purpose the use of sand pump dredges is being largely availed of; dredges of this class are being built of

very great capacity and enable the engineer to carry on his work at a rate which a few years ago would have been quite impracticable. In connection with the draft of vessels, it may be interesting to note that the depth of channel proposed for the Panama Canal is 35 feet. The present depth of the Suez Canal is 29 feet 6 inches, but it is proposed to deepen it throughout 34 feet 6 inches.

The difficulty in the way of keeping wharf accommodation up to the demands of the times, arises chiefly from the fact that ship building comes first in order of time, while the wharfage necessarily follows shipping developments. Moreover, shipbuilding is by comparison a rapid process. Even the large Trans-Atlantic liners take a relatively short time to construct. Great harbours, wharves, and docks, on the other hand cannot be as quickly completed. Existing wharves have to be demolished piecemeal and new structures of superior size and strength founded at greater depths, and all such works must be carried out without interrupting or hampering the existing trade of the port.

The superiority of the large over the small ship in earning capacity has become so insistently demonstrated, especially on long voyages, that the consequent growth in size of vessels coming long distances to our ports has rendered imperative the reconstruction of practically the whole wharfage of the chief seaports of Australia. It is very essential to us as a trading community that shipbuilding should not be hampered in development by inadequate berthing and docking facilities. How far this has been the case in the past is not easy to say. Probably it has not affected Australian shipping very much yet, but care must be taken that it does not do so in the future.

In our own city an auspicious commencement was inaugurated with the forming of the Sydney Harbour Trust

in 1901. The work of reconstructing the wharfage accommodation was at once taken in hand, and much has been done and is being done to meet the ever increasing trade of the port. When it is remembered that the shipping in Port Jackson has increased from 1,006 vessels of an aggregate tonnage of 385,161 in 1870 to 8,944 vessels of an aggregate tonnage of 6,901,057 last year, it will be realised what a difficult work it has been to provide adequately for the heavy tonnage of to-day at wharves constructed largely by private owners to suit their individual requirements, without system and without due regard to future expansion. The wharves at Circular Quay and at Woolloomooloo were constructed by the Government on lines which were considered at the time ample for many years, but even these have had to be largely reconstructed to meet present requirements. The reconstruction of the shipping acommodation in Sydney Harbour is but a typical example of what is being done in many of the principal harbours of the world. It will be found that in nearly all seaports of any consequence, the reconstruction of the wharfage will necessitate the remodelling of the city frontage streets, just as the developments in land transportation frequently require the remodelling of streets farther back. All this is of course slow and expensive work, but it will have to be done sooner or later.

The problem of the class of wharf construction best suited to the needs of the immediate future is one that has not yet been satisfactorily solved. Timber, which formerly served the purpose, is being largely set aside in Europe for several reasons. In the first place its life is brief owing to decay, and it is difficult to protect it from the ravages of marine borers, as the yellow metal which was at one time durable in salt water cannot now be relied upon.

Deep sea-walls have long been used, but with the increasing draft of vessels, the great height now required renders

such construction very costly and very slow. Iron and steel have been tried with success, but structural steel jetties are very expensive both in first cost and in subsequent maintenance. The latter item becomes a serious consideration, and marine engineers have been seeking for some time past to find a substitute, which, while of sufficient strength, will obviate the heavy maintenance charges.

Reinforced concrete has been devised with this end in view, and there are now many instances in existence which serve to show how successfully the principle can be applied to various classes of engineering work. It is in Europe chiefly, that reinforced concrete construction has been developed and perfected, and the formulæ for the computation of strength devised. In the United States, though a great many reinforced concrete structures have been built, the Americans have followed rather than led.

The application of reinforced concrete to wharf and jetty construction has not anywhere kept pace with the advancement of the same compositions on dry land. The greater number of wharves so built are more or less imitative of timber work. In this part of the world reinforced concrete wharves have been built at Auckland, Tonga, Wellington, Gladstone, Brisbane, and Adelaide, and they are all practically of similar design—pile and deck structures. Nothing of the kind has been essayed, so far, either at Sydney or Melbourne, though, at the latter port, this class of construction was recommended by the engineer engaged to report upon the Port of Melbourne in 1908.

It might be inferred from these facts that we, in Sydney, are getting behind the times, but such is far from being the case. Reinforced concrete has been applied in connection with our wharfage works, but following an entirely new line of development, we have not up to this constructed any reinforced deep water berths, but considerable progress

has been made in the direction of reinforced concrete sea-walling.

It may have been remarked that timber wharf and jetty construction still holds its own in Sydney Harbour, though to a large extent abandoned in Europe. Local conditions must, however, always determine the class of construction best suited to the services needed. In some parts of the world a high range of tide renders timber work less suitable than iron or steel, on account of the great length of piles required. Possessing as we do a port with a spring tidal range of only 5½ feet, and undoubtedly the best timber in the world for wharf construction, it is natural that we should make use of that timber as long as the supply lasts and can be obtained at a reasonable cost.

With the present heavy demand for first-class timber for use on our national works as well as for exportation, our forests are rapidly being thinned out, and it is inevitable that unless some drastic measures are shortly taken in connection with reafforestation and exportation, the time will come when sufficient first-class timber with which to carry on our works will be unattainable except at prohibitive cost. During the past year we have used in connection with Sydney harbour works alone 3,450 piles, 3,009 girders, and 1,186,000 super feet of decking and timber for shed-work. This has denuded at least 4,000 acres of our best forest country; when we consider the quantity of timber used in other harbour works, bridge building, and for various other purposes, we can realise how much of our iron-bark, turpentine, and other first class timbers is being cut out annually. Up to the present time no steps have been taken to replenish the supply.

What is locally going to replace timber for jetty construction is a problem that is by no means easy of solution. Timber is still being used in many instances at New York

and other American ports for the largest vessels afloat. As long as timber is available and can be protected from marine borers, or can be used where borers are not destructive, it possesses advantages both economical and structural, that commend themselves to the engineer.

Reinforced concrete wharves and jetties, such as have been built, so far, in Australasia, do not in my opinion afford a solution of the berthing building problem. Personally, I am disposed to deprecate the copying of timber pile construction in reinforced concrete. A timber pile possesses a high degree of resilience and in any lengths in which it can be obtained will bear the bending moment of its own weight while being lifted. A reinforced concrete pile, on the other hand, of 18 inch section, when beyond a comparatively short length, cannot be lifted without danger of fracture unless slung in two or three places. Indeed, the resistance of a reinforced concrete pile however well made is so low that it should never be called upon to resist either flexion or shock, or to sustain a transverse load. Experiments have shown that a reinforced concrete beam is only about a fourth or even less of the strength of an ironbark beam of the same section. Reinforced concrete piles that can only be lifted without fracture from a recumbent to a vertical position for driving, by slinging them in two or three places, certainly do not impress me as the most suitable support for wharves which often have to withstand shock and heavy side thrust from a vessel while berthing.

The use of ferro-concrete in work of this class has yet to stand the trial of time, and many well-known engineers in England are still sceptical as to its efficiency and lasting properties owing to the danger of the concrete becoming detached by shock and leaving the steel bars exposed to the corroding action of the water. It is very difficult to detect

damage of this kind under water, and still more difficult to satisfactorily effect repairs. One thing is quite certain, ferro-concrete structures of this class should only be placed in the hands of experts to carry out, as extraordinary care is necessary to secure reliable work. To allow the work to be executed by persons without considerable knowledge of the principles of its construction is simply courting disaster.

In other parts of the world groups of piles and cylinders have been tried with success, but from what we are able to judge of the cost of such work it seems highly probable that a sea wall could have been built for the same or perhaps even less cost, and would certainly have proved a more substantial class of construction. While offering these criticisms I do not wish to imply that I consider reinforced concrete unadapted to wharf construction. Quite the contrary, but I do think that thoroughly suitable methods have yet to be evolved.

The widely varying conditions under which harbour works have to be designed, prevailing winds and currents, rise and fall of tides, nature of material available, etc., make marine works a particularly interesting, as well as a difficult study, and yet perhaps in connection with no other professional work do we find so many amateurs ready to give advice and criticism.

Take for example, the much discussed question of the Sow and Pigs reef, near the entrance to Port Jackson. Some advocate its removal because it disfigures our otherwise beautiful harbour; others because it is a danger to navigation, while on the other hand, we heard an interesting paper read not long ago, advocating the construction at this place of extensive wharves and jetties to accommodate the whole of our over-sea shipping. This reef is some three-quarters of a mile long, at its eastern end,

where it rises in places above low water and dips towards the western channel carrying not more than twenty-six feet of water for some six hundred feet west of the beacon, its removal to give a depth of even thirty-three feet would therefore be a work of very considerable magnitude. We have no record of any vessel having grounded on this reef since the schooner "Isabel" touched there some eight or or nine years ago, and she was towed off by the Pilot steamer without damage, so that the reef has certainly not proved itself a danger to navigation, and I am strongly of opinion that its removal would from an engineering point of view be a serious mistake.

At present this natural training wall guides both the ebb and flood tide down the eastern channel, thus creating a uniform scour sufficient to keep it deep enough for our shipping requirements at a very small cost. In other harbour entrances breakwaters have been constructed at a great cost to effect the object that this natural guide wall now serves. The removal of the Sow and Pigs reef would undoubtedly reduce the scour in the Eastern Channel, with the result that frequent dredging would be necessary to obtain the requisite depth for the safe navigation of the harbour.

Another much debated question in this State is that of the improvements of our river entrances and bar harbours. The coast line of New South Wales extends nearly north and south for a distance of some 610 miles, and marine works have, up to this time, been designed and started in connection with nineteen river entrances and estuaries, but in very few cases have any of these works been carried out to completion as rapidly or in the manner that would ensure the best results. This has not been the fault of any of the many able engineers who have had to deal with these works in the past nor of the Ministers presiding from

time to time over our great Public Works Department, but is due to what I would call political expediency. The residents on each river in their, no doubt, justifiable desire for better means of communication to enable them to send their produce to Sydney and other large markets, have persistently advocated the improvement of their various waterways, with the result that the sums of money available each year for this class of work have been divided up so as to keep a number of these river entrance works going as far as possible, but, in many cases, partly completed works have of necessity been suspended for long periods, with the result that owing to the new conditions thus created, large quantities of beach sand have been drawn into the entrance on the flood tide and deposited in the form of new bars by the ebb tide, in some instances making the entrance more difficult than before the works were started. In other cases, owing to insistent agitation, it was found expedient to start those portions of the works which could be most quickly and cheaply put in hand. Two notable instances of this might be mentioned. There is no doubt that from an engineering point of view the southern breakwater at the Manning River entrance and the northern breakwater at Cape Hawke should have been the first works undertaken at these places, but owing to the time required to construct wharves and other preliminary work and to the cost, the breakwaters nearest to the quarries, which could be carried out more rapidly and at the smallest cost, were put in hand first, with the result that so far these works have not effected the improvements anticipated, nor can good results be expected until the works as designed, with probably some additions or modifications necessary on account of altered conditions caused by the works remaining unfinished for so long, are completed. Briefly, the results to be attained by the construction of training walls and breakwaters at our river entrances,

which in nearly every case consist of a rocky headland on one side and a sand beach on the other, are, (*a*) by the directing of the ebb and flood tides over the same line, to deepen and maintain river channels, (*b*) to increase the velocity of the current, so that the silt brought down by the ebb tide may be carried as far as, and be dispersed by, the littoral or coastal currents, (*c*) to prevent beach sand from entering the river on the flood tide, and (*d*) for the protection of shipping navigating the entrance.

If after careful consideration of all natural local conditions, tides, currents, winds, flood waters, etc., a scheme is prepared to achieve these objects, it is scarcely to be expected that the carrying out of a portion of that scheme will lead to altogether satisfactory results. Whether the area of agricultural land in the vicinity of some of our smaller rivers or estuaries is sufficient to justify the carrying out of works, which must necessarily involve a considerable expenditure to be successful, is not for me to say, but certainly any work put in hand for the improvement of a river entrance should be carried out to completion as quickly as possible and without interruption during its progress. The ever restless waves and other great forces of nature are constantly at work day and night, and similar activity is necessary on our part to successfully cope with them in work of this class.

Where ocean transport ceases and land carriage begins, there arises the problem of changing from one to the other, and much difference of opinion exists as to how this can be effected in the most efficient and economical way. A large majority of the modern cargo-carrying steamers are equipped with appliances suitable for the rapid handling of ordinary merchandise, and it seems to me superfluous to duplicate these appliances on general cargo wharves. In some ports in Australasia numbers of hydraulic and other cranes have

been erected at general cargo berths, but so far as I can ascertain, they are seldom used, and occupy much useful space on the wharves. For the loading of bagged wheat conveyors are most extensively used, and perhaps no better example of this class of gear can be found anywhere than in the port of Sydney at Darling Harbour, where an extensive system of electrically driven conveyors capable of loading some 12,000 tons of wheat a day into seven vessels, has been installed. I may add that in order to keep pace with the rapid increase of our wheat export trade, provision is now being made to largely increase this installation.

The question of coal loading appliances has been so much before the public of this State during the last year that it is not my intention to deal with it at any length this evening. I would, however, point out that the particular trade of a port and the class of vessels to be loaded, must be taken into account quite as seriously as the question of feeding the loading appliances, or the rapid discharge of coal from the trucks. At a majority of the coal-loading ports of England and America, the trade is carried on by steamers specially built for the purpose. These colliers are constructed with no 'tween decks and continuous hatches through which loading can be completed practically without trimming. The rate of loading is therefore largely governed by the capacity of the shore appliances. From other ports, such as those of Australia and New Zealand, coal is taken away for the most part by the ordinary cargo steamer, constructed with two or three decks and comparatively small hatches to suit the general cargo trade. With such vessels it is necessary to start trimming after a few hundred tons of coal have been deposited in a hold, and from that point the rate of loading largely depends on the rate of trimming. With vessels of this class there is often difficulty in depositing the coal without excessive breakage.

Owing to the geographical position of Australia and to the conditions of our commerce, it seems more than probable that for many years to come our coal trade will continue on its present lines. Any additional coal loading appliances to be erected at our ports should therefore be designed to suit that trade.

The question of discharging coal cargoes by mechanical means fitted in the vessel has received much consideration for some time past, and a steam collier with self acting delivery has lately been constructed at Sutherland, which it is said will reduce the cost of discharging a cargo of 3,100 tons to about one-tenth the cost of discharging by hand. The equipment consists of twin belt conveyors carried in a space under the cargo which draw the coal from the hold and deliver it by means of swivelling booms either into trucks on the wharf or into barges alongside the vessel. Discharging coal cargoes by means of conveyors and grabs worked from the shore has been carried on with considerable success for some time, but it is obvious that much better results should be obtained from an equipment fitted in the ship itself.

Owing to the limited time at my disposal for the delivery of this address, I have been able only to touch very briefly on a few of the many subjects connected with over-sea transport. The interesting and equally important question of transport by land must be left for someone better versed in the subject to deal with on some future occasion.

* * * * * *

During the past twelve months we have lost by death one Hon. Member, Professor Simon Newcombe, LL.D., Ph.D., Rear Admiral of the United States Navy; he was elected a member of our Society in 1901 and died on 11th July, 1909. The loss of ordinary members has been more severe. The death roll includes the following :—

The Right Hon. Sir Frederick Darley, P.C., G.C.M.G., Chief Justice and Lieutenant-Governor of New South Wales. Born in Dublin, 18th September, 1830, died 10th January, 1910. Elected a member 1877.

Mr. David Kirkcaldie, Assistant Railway Commissioner in New South Wales, died 5th September, 1909. Elected a member 1892.

The Hon. W. J. Foster, formerly a Judge of the New South Wales Bench, died 16th August, 1909. Elected a member 1881.

Mr. James Scargill Wade, Assoc. M. Inst. C.E., died 20th Oct., 1909. Elected a member in 1906.

Mr. J. U. C. Colyer, died 1910. Elected a member 1876.

In conclusion I have to thank the members for their kind support and consideration during my term of office. The year has been a fairly successful one, and many interesting papers have been read and discussed. I am sure we all look forward with pleasure and interest to the work of the coming year, presided over by so able a scientist as my successor Prof. David.

NOTE ON THE INFLUENCE OF INFANTILE MORTALITY ON BIRTH-RATE.

By G. H. KNIBBS, F.S.S., F.R.A.S., etc.,
Commonwealth Statistician.

[*Read before the Royal Society of N. S. Wales, June 1, 1910.*]

THIS subject was dealt with previously.[1] The measure of the effect of infantile mortality may be thus rigorously determined :—

Let the total number of births be denoted by B and deaths of infants be denoted by M, and let it also be supposed that the number P of women of child-bearing age in any community is constant, and constantly distributed in the same manner with respect to age, or rather reproductivity. Then for the present purpose the birth and infantile mortality rates with respect to this element of the general population may be represented as follows, viz.:

$$(1) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \beta = B/P$$

$$(2) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \mu = M/B$$

respectively. The rates of infants dying to the women of child-bearing age is thus $\beta\mu$. To determine the effect on the birth-rate of any change in the rate of infantile mortality, let the latter be supposed to change to some new value $\mu' = M'/B'$, M' being the number of deaths and B' the number of births under the changed condition after it has become constant. In both cases the women whose children have died will be added to the number at risk, that is, the number who may increase the number of births. In general however, this risk will be less than that of the remaining women of child-bearing age who have not borne children.

[1] This Journal, Vol. XLII, pp. 238 - 250.

We may suppose that this risk becomes effective in the constant proportion q only of the whole, q ordinarily being less than unity, and in no case greater than unity. So long as the first birth-rate and infantile mortality remain constant, the number N at risk, assuming, as we may without sensible error the absence of multiple births, is

$$(3) \ldots\ldots\ldots\ldots \quad N = P - B + q\,M.$$

When a change of rate of infantile mortality supervenes, the number of births must as stated be obviously affected if the reproductivity remain constant, for the number at risk N' under the new conditions is

$$(3a) \ldots\ldots\ldots\ldots \quad N' = P - B' + q\,M'.$$

That the reproductivity of these two groups N and N' shall be identical, it is necessary that the ratio of B to the first shall be identical with that of B' to the second, that is $B/N = B'/N'$. Hence taking the reciprocals of these quantities, we have

$$(4) \ldots\ldots\ldots\ldots \quad \frac{P + q\,M}{B} - 1 = \frac{P + q\,M'}{B'} - 1.$$

But B/P and B'/P are the initial birth-rate and the birth-rate as changed by change of infantile mortality, say β and β', hence after throwing out the unit on each side this last equation becomes

$$(5) \ldots\ldots\ldots\ldots \quad \frac{1}{\beta} + q\,\mu = \frac{1}{\beta'} + q\,\mu'$$

which may be written

$$(5a) \ldots\ldots\ldots\ldots \quad \frac{\beta}{\beta'} = 1 + \beta\,q\,(\mu - \mu')$$

This is the fundamental relationship between the rates considered. This formula may be simplified in practical applications. Since the quantity to be algebraically added to unity is in all cases very small, it will be sufficiently accurate to write

$$(6) \ldots\ldots\ldots\ldots \quad \beta' = \beta\,\{\,1 + q\,\beta\,(\mu' - \mu)\}$$

which indicates that the change is sensibly a linear one,

that is that any increment to the rates of infantile mortality will cause a sensibly constant proportional increase to the birth-rate, but this increase must in any case be very small.

One may consequently suppose that a birth-rate β_0 may be deduced which would be free from the effects of infantile mortality. This last equation may be put in the form

$$(7) \quad \ldots\ldots\ldots\ldots \quad \beta_0 = \beta\,(1 - k\,\mu)$$

in which β is the actual birth-rate, k a constant for a particular community at a particular epoch, and β_0 the rate freed from the influence of infantile mortality. This equation is the same as (9) on p. 241 of the paper quoted, illustrated on p. 243, and tabulated on p. 244. It gives for Europe the average result

$$\beta_0 = 22{\cdot}8 + 0{\cdot}033\,\mu.$$

the value of β ranging from 12·9 to 38·9 and of k from $-0{\cdot}07$ to $+0{\cdot}19$. Theoretically it should always be positive.

Further refinement in the theory so as to take account of the influence of change of population, is, in the light of the plotted results shewn on p. 243 in vol. XLII, referred to, unnecessary.

THE GREAT WEATHER CYCLE.

By T. W. KEELE, M. Inst. C.E.

[With Plates I, II.]

[*Read before the Royal Society of N. S. Wales, June 1, 1910.*]

"Cycles of the Seasons are as certain as the laws that govern the Heavenly bodies, though we have not yet been able to fix their period. It is of atoms that the Universe was made, so it will be the combined work of many that will enable us to arrive at those meteorological truths which it is so desirable to discover, and which may (when once discovered) prove of so great and lasting benefit to mankind."[1]

In a paper read before this Society by the late Mr. H. C. Russell, on October 11th, 1876, on "Meteorological Periodicity," he prefaced his remarks on the subject by a quotation from Lockyer on "Solar Physics," as follows:—

"Surely in Meteorology, as in Astronomy, the thing to hunt down is a cycle. If it is not to be found in the temperate zones, then go to the frigid zones, or to the torrid zone to look for it, and, if found, above all things lay hold of it, record it, and see what it means. If there be no cycle, then despair for a time if you will, but yet plant firmly your science on a physical basis, and wait for results."

In the spirit of these remarks, Mr. Russell said he had attempted to bring some facts together bearing upon meteorological cycles, but from the difficulty of obtaining detailed observations for long periods, and for many places, he was obliged to confine what he had to say to Australia, though he hoped to be able to show that we are bound by the same meteorological causes which rule the northern

[1] E. L. Lowe, F.R.S., Highfield Observatory, Nottingham, (*Notes and Queries*, 5th series, VIII. p. 507, 1877.)

hemisphere, except in so far as local peculiarities modify the weather, which results from cosmical causes.

After referring to various meteorological cycles which have been propounded from time to time, none of which were satisfactory, he proceeded to explain the results of his own investigation which, he said, had convinced him that in a period of nineteen years the general character of the weather returns. He did not mean to say that there will be the same wet, or the same amount of dry weather in every year of a series; but that the general character of the years in each series will be the same. He said he had detected the period in our rainfall observations, and the suggestion was first made, so far as he was aware, in his "Notes on Climate of New South Wales, 1870," in which a diagram was published, including results from 1840 to 1869.

Since then Mr. Russell had accumulated a large amount of valuable information bearing on the question, which, although not conclusive, was sufficient to cause him to believe there was an amount of probability in its favour that will justify at least a careful examination.

Mr. Russell's next paper on the subject was read before this Society on 9th June, 1896, entitled "On the periodicity of good and bad seasons." In the interval of twenty years from the date of his previous paper, he had, with unwearying patience, continued to pile up further facts in relation to the weather, and these, together with investigations into the floods on the Darling and the floods in Lake George, and a careful study of the rainfall and general weather statistics, and the diagrams of various weather records, barometer, thermometer, wind duration, and force, and rainfall of different Australian latitudes, from 1840 to 1887, had convinced him that there was a periodicity in weather.

The argument of his paper was that if one hundred years of climate be carefully studied so that the salient features are clearly defined, and this section of time be compared with all past time, so far as data are available, and it is found that the salient points in our century are repetitions of the salient points in all past time and probably in all countries, then one is justified in coming to the conclusion that those salient points are definitely connected with the climate of the world, and will appear again regularly in the future. The weak point, he said, was freely admitted, namely, that history has not kept a regular and continuous account of droughts, but only recorded those which became very prominent. The strong point was that all the data that history does give us are in favour of the nineteen years' cycle.

Although the evidence he had collected in support of his theory appeared to him to be conclusive, he realised the difficulty in demonstrating it to others, and it occurred to him that it would be useful to have a diagram in which all the droughts, without regard to their intensity, be placed in their order of time. Not only was this desirable for seeing what the relation in time was, but it had become evident that it would be impossible to see the relation between our droughts and those in other countries, unless some such pictorial arrangement was made. He accordingly constructed a diagram in which was shown the various droughts in a cycle of nineteen years, which he marked A, B, C, D, E. It was thus seen that drought 'A' was regular and occurred every nineteen years. Drought 'B' was found to recur with nearly the same regularity. The remaining three also recurred with an average interval of nineteen years, but they were not quite regular, may in fact, differ from time to time a year, or even two years.

Having prepared his diagram in this manner he proceeded to show that nearly all the great droughts of Australia

had their counterparts in India, and that the great and conspicuous droughts of history all drop into the cycle, not only those that happened before the birth of Christ, but those that have occurred in our era; also, that great hurricanes, the great frosts of history, all the red rains, and all droughts that history records, with very few exceptions, are likewise included in the cycle; and that the levels of the great lakes in Palestine, South America, and New South Wales, are subject to the same mysterious influence that controls our weather.

With regard to causation, Mr. Russell said that, as his investigation proceeded, the weight of evidence gradually converged upon the moon as the exciting cause. He said he had never had any sympathy with the theory of lunar influence upon weather, and received, rather against his will, the evidence that presented itself; but the logic of facts left no alternative but to accept the moon as prime motor. He explained that he had not had time to complete his investigation, but when finished it would form another paper.

For convenient reference, he had put on the diagram the maxima and minima of sun spots, and it would be seen that the recurrence of the period is very far from being the regular eleven years' cycle which many persons supposed it to be, and it was equally far from being in accordance with the cycle that he had endeavoured to demonstrate.

In the discussion which followed the reading of this paper, Mr. Russell was complimented on the very able manner in which he had tackled a very difficult question. It was, however, generally held that he had not successfullv demonstrated that a nineteen years' cycle exists in the weather of the world, and by one member, at least, the paper was subjected to very adverse criticism, Mr. Russell's reference to B.C. droughts, and their dates, particularly the biblical droughts, being ridiculed.

I am sorry Professor Gurney is not present to-night, as I think the evidence which I have now to bring forward in regard to the recurrence of those B.C. droughts, would cause him to considerably modify his opinion, and, at least, to confess that there was some force in Hamlet's reply to Horatio—

"And therefore as a stranger give it welcome. There are more things in heaven and earth, Horatio, than are dreamt of in our philosophy."

Mr. Russell's last paper on this subject was read before this Society on 4th September, 1901, wherein he endeavoured to show the moon's influence upon the weather by means of a diagram, in which the annual rainfall at a number of stations in New South Wales and Victoria with the longest records was shown by vertical lines to a scale, together with a curve showing the greatest southern declination of the moon for each year, his contention being that the changes in the rainfall, as shown in the diagram, were undoubtedly coincident with the positions of the moon. He said—

"I do not mean to say that I have demonstrated that the moon is an active point in the weather, but I think the rain is shown so clearly to come at times of abundance when the moon is in certain degrees of her motion south, and when the moon begins to go north then drought conditions prevail for seven or even eight years, a phenomenon repeated for three periods of nineteen years each, that it is either a marvellous coincidence, or there is a law connecting the two phenomena. I am convinced there is some connection between the two."

I have quoted so fully from Mr. Russell's papers on this subject, in order to refresh your memories concerning the arguments he, from time to time, brought forward in support of his theory, to which he tenaciously clung from the time he first propounded it in 1870 until his death in 1905.

Whether he was right or not in his conclusions remains still to be proved, but I feel sure you will agree that we owe him a deep debt of gratitude for all his labour in this direction. The facts he accumulated with so much patience and sagacity are of the utmost value to enable the subject to be followed up.

It must be remembered that he was not alone in his views concerning periodicity in the weather. In our own State he had the support of two of our most distinguished scientists, namely, the Rev. W. B. Clarke, and Professor J. Smith, both of whom worthily filled the Chair of this Society, and quite recently confirmation of the correctness of Mr. Russell's conclusions as to the nineteen years' change in the weather is given by Colonel H. E. Rawson, C.B., in a paper read by him before the Royal Meteorological Society on 15th April, 1908, in which he shows that in South Africa the range of the anti-cyclonic belt varies from $24\frac{1}{4}^{\circ}$ S. Lat. to 34° S. Lat. in a period of nineteen years, and these cyclonic changes are coincident with the changes of the weather from wet to dry, and vice versa, a fact which he acknowledged had been noticed by Mr. Russell in a paper contributed by him to the Royal Meteorological Society in December 1892.

I will now proceed to explain the work done by myself, in order to ascertain how far reliance might be placed on the theory of nineteen years periodicity in weather. I may say that from the time when Mr. Russell read his first paper in 1876, I have always been in sympathy with his views on the question, and although I regret I was unable during his life time to afford him any assistance, it is a source of great satisfaction to me now (making use of the information he so laboriously collected, but arranging it under a different system, and with the help of data which he did not possess) to be in a position to lay before his critics the proofs they declared were unattainable.

To those who will carefully and impartially study Mr. Russell's work, it will be seen he realised that each place has its own peculiar period; but he was confident that it would ultimately be found that the nineteen years' period, if not continually repeated, would be found to be a constituent part of a longer period; the following quotation from his paper in 1876 will explain this, and also account for the failure of his prediction in 1896 of good seasons to come in 1897-8, and in 1901-2 :—

"Surely we have here enough to justify a strong suspicion, to say no more, that we have waves of drought passing over the earth, that we have an outside cause for the phenomenon that has puzzled us so long—a phenomenon which we have every reason to believe is subject to laws as definite as those which hold the planets in their places, and the knowledge of which is fairly within our reach, if we have but patience to take the uphill way that leads to it. Nor must we at once assume that, if a period is proven at one place, we shall find the same at another. There is, I think, unmistakable evidence of several involved periods; out of the combination of these with local circumstances come the results there observed; like the vibrations in musical notes, they will 'beat' just in accordance with the conditions existing. For instance, with one of the waves of drought we may have the conditions which shift the trade winds, and send a comparatively plentiful rainfall; or we may have a number of forces at work which shall make the nineteen years' cycle of one place the thirty years' period of another."

The diagram which I now submit for your inspection, (*Plate 1*) illustrates in a most remarkable manner—on the testimony of the river Nile—that his ideas on the subject of periodicity in weather, which he so eloquently expressed in the foregoing statement, were in the main correct. A close study of the diagram will, however, show that his views concerning the nineteen years' period will have to be considerably modified, as it evidently has not universal application.

Although in some of the curves (Plate 2, fig. 1) notably Horsham and Adelaide, a series of waves at nineteen years' intervals are clearly defined, it will be observed in the Nile's curve—whose period appears to be one of 171 years, built up of three periods of 57 years, which in their turn are composed of three periods of 19 years—that the nineteen years waves are obliterated in the first great sweep made by the accumulated rise from 1736 to 1781, and also in the decline made by the accumulated fall from 1782 to 1839. In the second great sweep of 57 years from 1839 to 1896, the Nile's wave, having lost the energy it possessed in the former wave, permits the smaller waves of which it is composed to be seen, but they are hardly discernible.

It is fair to Mr. Russell to remember that he had very slender data to work upon in formulating his theory, but it is quite evident from the quotation previously referred to, that he had more than a suspicion that his nineteen year period was involved in a greater one, but he was unable to demonstrate it.

On a first glance at the diagram, which looks a little complicated owing to the variety of curves there delineated, the slow secular change in the Àbyssinian rainfall, which results in the annual inundation of the Nile, may not be immediately discernible owing to the unusual system I have adopted in depicting it, by the construction of the residual mass curve; but on a careful study of the diagram, the truth, I hope, will become revealed to you, as it has been to me, and you will then be better able to appreciate the work previously done by Mr. Russell, who had no information concerning the Nile, and to realise with what rare judgment, amounting almost to prescience, he was endowed.

In my diagrams (*Plates 1, 2*) you will observe that I have made the fluctuations of the water in Lake George, New South Wales, a conspicuous feature, and that the annual

measurements of rainfall at the various places selected, as well as the heights of the Nile River floods, have all been converted into residual mass curves. The term is not strictly correct where evaporation has not been allowed for; but the fluctuations of the water in Lake George, when drawn to scale as shown in the diagrams, make a curve representing the true residual mass, for the reason that the lake may be regarded as a large natural rain gauge, having no outlet. The water stored in its basin is the residue of the total amount which has fallen upon its catchment area, after evaporation has done its work. If the levels of the water surface, therefore, can be relied upon throughout the whole period under review, the curve derived from it is a better means of detecting periodicity, if it exists, than by any artificial gauging not corrected for evaporation. It appeared to me that if the measurements of rainfall at the various stations, and also the heights of the Nile floods, be reduced in such a manner as to show the accumulated rise and the accumulated fall, above or below the mean, the curve thereby derived would be better for comparison with the Lake George curve, than by any other method. The results are now before you, and you will be able to judge whether or not it is preferable to the other methods ordinarily in use. I do not claim any originality for this system. It was adopted by me after studying a report by the Commissioners appointed to inquire into the New York Water Supply, wherein I noticed that the method had been used by Mr. Walter E. Spear in his investigation of the Long Island Water Supply. The following is an extract from his report:—

"Since the height of the water table—on which depends the delivery of the ground water on Long Island—represents the *cumulative* effect of the rainfall for many years, it was appreciated that the ordinary method of considering the maximum delivery of a watershed to depend upon the rainfall during the driest

season, or during the driest year, would not necessarily give the lowest yield; for if the season or year of drought followed a period of heavy rainfall, the water table, having been raised during the rainy years, would still deliver during the period of drought, a large amount of water that had fallen during the previous years. Consequently the residual mass curves were worked up. The general agreement between these mass curves and the fluctuations in the elevations of the ground water justify their computations."

The importance of the Lake George record was recognised by Mr. Russell very early in his investigations, and in his paper of 1876 he supplied information concerning its fluctuations from the date when the lake was discovered in 1820 by Sir Thomas Mitchell. On 1st December, 1886, he read a paper before this Society entitled "Notes upon floods in Lake George," in which he described all the work done by him in his endeavour to ascertain the level of the water in the lake from time to time. The records of the Lands Department were searched to enable the margin of the water to be determined from old surveys. Further information was obtained on the spot by himself from old residents, and the diaries of explorers and settlers were also looked into, in order to obtain information. Finally a surveyor was instructed to connect all the points obtained by direct levelling. In this manner Mr. Russell was able to construct a diagram, which he appended to his paper, showing the conditions of the lake with approximate accuracy from the year 1820 to 1885, in which latter year he established a self registering instrument similar to an automatic tide gauge, such as we have at Fort Denison, which has registered accurately the fluctuations of the water up to 1907, since when they have been unfortunately discontinued. It is to be hoped, however, that the authorities will recognise the very great importance of continuing the record. The small expense of keeping the register, and attending to the

gauge, would surely be justified when its importance in comparison with other Meteorological Stations is considered.

The sheets taken from the barrel of this instrument were regularly sent to the Observatory at Sydney, where they have been filed for reference. With the help of these records from 1885 to 1907, and the previous information supplied by Mr. Russell, I completed his diagram and have shown it on mine in full black. This represents all that is positively known about the condition of the lake, and on comparing it with the residual mass curve, constructed from the Sydney rainfall record (*Plate 2*, fig. 1) the value of the new system I have adopted of showing the cumulative effect of the rainfall, as exemplified in the Sydney residual curve, became apparent to me, and all doubt as to the correctness of the earlier Sydney register of rainfall was at once removed. I then plotted on the diagram the Adelaide, Horsham, Bathurst, and Hobart curves, and, making allowance for local circumstances, there appeared to me to be evidence of periodicity which, although it was not in strict accordance with the nineteen years theory, still I felt convinced that a marked change at that interval was clearly observable in all the curves.

Devoting my attention to the Lake George curve, it occurred to me that it closely resembled a complete period, rising, as it does, out of the dry bed of the lake to a maximum of 24 feet of water in 1875, and returning again to the dry bed after a period of 57 years. Working on that assumption I extended it backwards into the past from the year 1820, in the manner you see on the diagram. I also wrote in the general character of the weather in New South Wales, as obtained from Mr. Russell's paper of 1876, from the date of arrival of the first colonists in 1788 up to the time when the rainfall began to be registered in 1831. On comparing this with the assumed level of the water in

Lake George, I was much impressed with the general agreement. For instance, the fearful drought[1] experienced by the first colonists from 1788 to 1794 coincided with the assumption that Lake George was dry during that time, and again, we know that the first flood[1] the colonists experienced occurred in Sept. 1795, which fact exactly coincided with the assumption that the lake rose in that year to about the same level that it reached in 1852 (namely, 12 feet) 57 years afterwards.

If we may judge from the weather we have been experiencing during 1909, and the present year (1910), which, if there is any truth in the theory, should be the meteorological counterpart of 1795-6 and 1852-3, the lake should be rising again, after a similar period of drought, resulting in a dry lake bed which preceded those years. In this connection it is interesting to note that, while at Adelaide in South Australia, and at Horsham in Victoria, and also that portion of New South Wales to the westward of the mountain range, they are having splendid seasons with rain much above the average, similar to what they experienced in 1852-3, we in Sydney, and generally along the coastal region eastward of the mountain range, were afflicted with drought during 1909, the rainfall up to the 31st December being 15½ inches below the average. The meteorological conditions were similar to those in 1852, but of greater intensity, the rainfall being then 4·57 inches below the average.

The description of the weather conditions experienced at that time, as given in the *Sydney Morning Herald*, was so like what we have recently had that the leading articles of 27th November, 1852, and 19th January, 1853, might almost have been adopted, with but slight alteration, to describe the conditions at the same dates in 1909-1910.

It is recorded that on the 26th June, 1852, a flood occurred in the Murrumbidgee River, which swept away

[1] "History of New South Wales from the Records," Britton, II, p. 260.

the small village of Gundagai, and out of a population of 250, 89 persons were drowned. Similar flood rains occurred in August 1909 over the Murrumbidgee and Murray valleys,[1] resulting in floods of similar character to those in 1852.

In June 1853, $14\frac{1}{4}$ inches of rain were registered at Sydney, $2\frac{1}{3}$ inches in July, and 7 inches in August. The June rains thoroughly saturated the County of Cumberland and extended far into the interior, resulting in floods in the Hawkesbury and Nepean Rivers, and also in the Murrumbidgee River. The latter rose to 39 feet 6 inches at Gundagai on 3rd July, 1853, being the highest ever experienced before, or since, that time.[1] *It remains to be seen whether that flood will be repeated this year.*

Before leaving the subject of Lake George, I should like to place on record some information which has been kindly supplied by Mr. Robert S. Archer concerning a somewhat similar, but much smaller lake, in Queensland, namely, Lake Gracemere, near Rockhampton, which was reported to be dry in 1858 after a very serious drought. Mr. Archer says:—

"I know that the 'Mere' was dry in the end of 1855 when the place was first stocked. In 1864 there was a high flood, the highest known, the house being surrounded by water. 1877 was a very dry year, also 1883, 1884 and 1885. At the end of the latter year the 'Mere' was very low, and all the fish died. In 1890 we had a good flood, also in 1894 and 1896, the latter being the highest I have seen here. 1900, 1901 and 1902 were three very dry years, and in September 1902 the 'Mere' was dry, except for two small pools, perhaps an acre in extent, with only a few inches of water, in which even the eels died. On 27th September 1902 a heavy thunderstorm put three or four feet of water into it, although it was not filled until January 1903. Since then we have had no heavy floods or severe droughts."

The rainfall was, however, below the average each year up to 1908, when I am informed the lake was again dry.

[1] Commonwealth Bureau of Meteorology. Bulletin No. 3, Nov. 1909.

These records of the behaviour of the water, entirely derived from the rainfall, stored up in depressions having no outlet, natural rain gauges in fact, corrected for evaporation, are of the utmost value in an investigation to determine the question of periodicity, and as Lake Gracemere has shown a similar fluctuation to Lake George, I thought it would be of interest to refer to it as I have done.

Turning again to the diagram (*Plate* 2, fig. 1), and particularly to the Adelaide curve, it is surprising to me that the 57 years' period, built up as it undoubtedly is of three periods of nineteen years each, has not, up to the present time, been detected in it. The reason perhaps is that by the ordinary method of showing the rainfall by vertical lines to scale, it is difficult to discern it; but, when the rainfall returns are converted into a residual mass curve, the truth becomes immediately revealed. Take particular notice of that portion of the Adelaide curve from 1840 to 1852, and compare it with the portion from 1897 to 1909, and note the wonderful agreement. The great drought ending in 1845, and the subsequent rise for seven years to 1852, is faithfully repeated 57 years afterwards in that portion of the curve from 1897 to 1902 and on to 1909. With reference to the 1902 drought, and its counterpart in 1845, note the similarity of the Adelaide and Nile River curves.

At this stage of my investigation, I became curious to ascertain whether the moon's south declination curve, or the sun spot curve, would afford any clue as to causation, if compared with the Lake George curve as extended, and the other curves I was in possession of at the time. I accordingly plotted on my diagram the moon's curve as far as 1846, as shown by Mr. Russell, and then extended it backward as far as the diagram permitted. Wolf's proportional numbers denoting sun spot frequency were obtained from Table XXVIII, as published in the Encyc. Brit.[1]

[1] Ninth Edition, Vol. XVI, p. 178.

and these enabled me to correctly delineate the curve, instead of showing only the maxima and minima of the spots, and connecting these points by straight lines as is sometimes done. On a first inspection, I must confess that I thought some coincidences could be traced in the combination of the curves in their relation to the Lake George curve; but when carefully studied I soon realised that so far as the moon's curve is concerned, there can be no real agreement between a curve resulting from a periodicity of 18·6 years as the moon's curve is and one based on the assumption of nineteen years' periodicity, for the reason that in course of time one would be seen to be slowly creeping over the other. The sun spot curve is so very irregular within the limits of the diagram that nothing tangible results from a comparison with the Lake George curve as extended back into the past. It is possible, of course, on the assumption of 114 years' periodicity, which the Nile curve would appear to indicate (*Plate 2*, fig. 1), or of even the longer period of 171 years which can be traced in that curve, and also in the British rainfall curve (*Plate 1*), that the peculiar curve of sun spot frequency may be found to be repeated; but unfortunately we have no reliable data so far back as to afford a comparison, and must perforce wait for future developments.

The Nile River Floods.—I had long wished for some definite information concerning the heights of the Nile River floods, in order to ascertain whether there were any indications of periodicity in the rainfall over its catchment area in the Abyssinian table land, and I was much pleased to find in Colonel H. E. Rawson's paper on "The Anti-cyclonic Belt of the Southern Hemisphere," previously referred to, a table giving the ratios of annual Nile floods to the mean flood from 1869 to 1905, taken from the Report of the Director of the Egyptian Survey Department. I

converted these into a residual mass curve, and plotted it on my diagram for comparison with the other curves. It will be seen that the cumulative effect of the rainfall from which the floods are derived, with reference to the mean, produces a curve which clearly shows the wet and dry periods of the Nile to be co-terminous with that of Lake George. The change from dry to wet which took place in 1888, and the remarkable rainfall of 1887, which immediately preceded that change, is very clearly defined in all the curves, and in many others which I have been unable to include in the diagram for want of space.

I was so much impressed with the results obtained from that portion of the Nile record in my possession, that I immediately wrote to Captain Lyons, the Director General of the Egyptian Survey Department, at Cairo, requesting him to furnish me, if possible, with information which would enable me to extend the curve backwards into the past. He very kindly sent me his report, dated 1906, "On the Physiography of the Nile River and its Basin," a most valuable and exhaustive systematic exposition of the whole subject. That portion of his report dealing with the "Variation of the Nile Floods" is of very special interest in this connection. I found that Captain Lyons had been engaged on a similar investigation of the Nile River flood records for traces of periodicity, and among numerous diagrams, he prepared one[1] showing the variation from the mean values of the Nile floods from 1737 to 1800, and from 1825 to 1903, in which the curve derived from the yearly values, and that computed from the means of successive five yearly periods, are compared with the sun spot curve. Unfortunately there is no information available to fill in the gap between 1800 and 1825; but I afterwards found that it occurs in a portion of the whole record, where it is felt less than it would have been if the gap had occurred

[1] See p. 42.

at one of the critical periods of secular change which I have discovered in the curve.

The results obtained from the available records of the Nile River floods are given here for the first time, reduced to a residual mass curve, and are of value in accordance with the amount of reliability that can be placed on them. Captain Lyons discusses the various Nilometers which have been found, and the records obtained from them, in much detail. The following are extracts from his report :—

"The data available for a discussion of the Nile floods are not inconsiderable but the greater part of them are, unfortunately, of very unequal value, on account of the irregularity of the readings at the Roda Nilometer at Cairo, and of the falsification of its records, which is stated to have taken place in earlier times in order to increase the revenue. They may be summarised as follows:

(1) Readings of the Roda Nilometer from A.D. 700 to 1905, and since the Delta Barrage has been in use the low stage readings have been affected by the artificially raised water level.

(2) Readings of the Nile gauge at the Delta Barrage from 1846 to 1878.

(3) Readings of the Nile gauge at Aswan from 1869 to the present time.

(4) Readings of the Nile gauge at Wadi Halfa from January 1890 to the present time.

(5) Readings of the Khartoum Nile gauge from 1869 to 1883 and from 1900 to the present time.

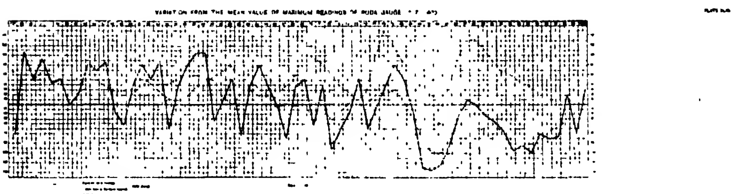
" By using the Roda gauge from 1825 to 1872, and the Aswan gauge readings from 1869 to 1902, and the Wadi Halfa gauge for any subsequent years, we have a series of maximum readings of the Nile flood for 80 years, which are very fairly accurate, since for almost every year there was another gauge which was simultaneously recording the river levels.

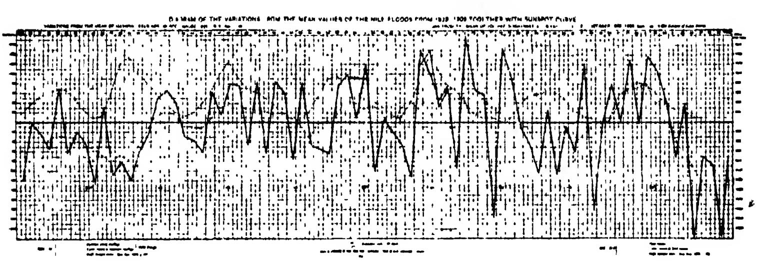
Period.	Gauge.	Verified by.
1825 – 1845	Roda	Barker, Holroyd, Bowring, Curzon, etc.
1846 – 1872	Roda	Delta Barrage gauge.
1869 – 1902	Aswan	Roda Barrage and other gauges.
1890 – 1904	Wadi Halfa	Aswan, and many other gauges.

"These maxima may be geographically represented by plotting them as differences from the mean value.

"These data should show some signs of an alternating series of high and low floods, that is, of a periodicity in the floods if such does exist.

"On Plate XLIII the Nile floods for 78 years, 1825 - 1903, are shown as well as an earlier series of 64 years from 1737 to 1800.





"Since the Nile flood is the direct result of the June – September rainfall on the Abyssinian table land, the rains and the meteorological conditions which determine them must be subject to a similar oscillation to that which is so markedly shown in the flood diagrams.

"Essentially the succession of Nile floods for the last 80 years is an oscillation between floods above the average and floods below the average, and the same thing is seen in the series from 1737 to 1800, though the range of oscillation is not so large, if the observations can be relied on.

"The long series of years following 1738 in which the Nile flood was almost invariably good is corroborated by Bruce, who writes:—

'The Nile for these thirty years has but once so failed as to occasion dearth; but never in that period so as to produce famine in Egypt.' This refers apparently to the thirty years previous to 1773, the low Nile being perhaps that of 1772. He further speaks of three of these floods having been exceptionally abundant, which would apply to those of 1757, 1758, and perhaps 1753. The exceptionally low floods of 1783 and 1784 are mentioned by Volney, who speaks of them as causing a serious famine.

"For comparison with this earlier series of years, rainfall data do not exist as for the nineteenth century, still it can be said with certainty that the curve is not one which shows any more similarity to the alternating dry and wet groups of years, having a period of about 35 years, than has been found in the later series.

"We may conclude then with reference to the variation of the Nile flood from year to year, that no trace appears of any such definite periodicity as might be of assistance in estimating the probable duration of any succession of high or low Nile floods.

"In the sixty-four years (1736 – 1800) of the eighteenth century the oscillation between excessive and deficient floods is on the whole much the same as for the nineteenth century.

"The long period from 1781 to 1799, when apparently all floods, except two, were below the average, prevents any average length of the oscillation between floods in excess or defect being estimated satisfactorily. Essentially, then, the Abyssinian rainfall which is represented by the Nile flood, fluctuates at short intervals, and does not increase more or less regularly for a period of years, and then decrease in a similar way. These fluctuations are short, and if the number of years between the different crests of the curve be taken (whether such crests rise above the average or not) the length of time between such crests is :—

2	years in	12	cases in	the nineteenth	century
3	,,	6	,,	,,	,,
4	,,	3	,,	,,	,,
5	,,	4	,,	,,	

2	*years in*	*5*	*cases in*	*the eighteenth*	*century*
3	„	2	„	„	„
4	„	4	„	„	„
5	„	2	„	„	„
8	„	1	„	„	„
11	„	1	„	„	„

"We have therefore to deal with a comparatively short period variation in the meteorological condition; but this subject requires further investigation."

From these extracts from Captain Lyons' report it will be seen that, under the system he adopted of showing the variations from the mean values of the Nile floods "*for a period of 175 years during which the records have all the appearance of being comparable and reliable, no regular alternation of high and low floods is to be found.*"

By using exactly the same data, but treating it under a different system, namely, by finding the exact variations of the maximum readings of the annual floods above or below the mean, and then ascertaining the *cumulative effect* with reference to the mean, it will be observed that a curve is produced which still defines, although not so sharply, the alternations of high and low floods; but the *cumulative effect* of the variations from the mean is clearly brought out, and slow persistent rises and falls become observable, thus enabling not only the alternations of the wet and dry periods to be determined, but also, what is of the greatest importance, slow secular change, if such exists, can be detected by this system better than by any other that I am aware of.

It has already been stated when dealing with the Lake George curve, that there were good reasons for believing that it represented a 57 years' period, made up of three periods of nineteen years each, and on searching the Nile curve to ascertain if such a period could be traced in it, I

noticed that the lowest point in the whole curve occurred in 1839, when it was evident that the Nile curve was in exact agreement with that of Lake George, both curves culminating in the maximum intensity of drought in the same year (1839).

The highest points in the Nile curve occur at two places, one on each side of the lowest point. The distance in time from it being closely approximate, in one case to 57 years of accumulated fall, and in the other to exactly 57 years of accumulated rise. Moreover, when it is seen that the crests are each preceded by long accumulated rises over similar features of the assumed Lake George curve, one can hardly avoid the impression that such peculiar agreement in the variation of the curves cannot but result from the same mysterious influence whatever it may be.

The fact that the lowest point in the curve in 1839 is not exactly equidistant in time from the crests may, perhaps, on further investigation of the Nile records, be found to have occured through an error in converting the original observations, which were made according to the Coptic (Julian) Calendar, into the corresponding Mohammedan years. Captain Lyons in his report mentions this difficulty in a footnote, and explains the method adopted in endeavouring to obviate it. He does not place the same amount of reliance on the accuracy of the first portion of the Nile record from 1737 to 1800, as from 1825 to 1905.

The interval of time between the two crests shown on the curve of the Nile floods, being apparently 114 years, made up of approximately equal periods of 57 years, one of accumulated rise, and the other of accumulated fall, would seem to indicate that secular change will occur in that order, in which case the curve, having recently attained to the maximum in 1896, there should subsequently be a repetition of the weather on the Abyssinian table land

which produced the curve similar to that experienced onwards from 1782.

That an accumulated fall has been taking place is true. It will be seen however that during the nine years which have elapsed since 1896, the rate of fall has been much greater, nearly twice as great as during the same period following 1782, the intensity of the drought therefore in the former case has been far greater than in the latter, and if the long periods of accumulated rise preceding the two crests be examined, it will be seen that they are not exactly similar. It is possible, therefore, that repetition of similar weather may not be taking place in this order, namely, of 114 years, but that the period may be one of even longer duration, namely, of 171 years, or three times 57 years, in which case the rapid fall which has been experienced since 1896 may have terminated in 1907, and the curve may now be on a constant upward rise, similar to that shown from 1736 onwards.

That there is a considerable amount of probability in this assumption being correct may be realised on an inspection of the curves derived from two of the longest rainfall records in the world, namely, that of Britain and Padua, and comparing these curves with that of the Nile floods.

Note.—This was written at the time when the information I possessed concerning the Nile extended only to the year 1905. I have allowed this portion of my paper to stand as I originally wrote it, as it shows the difficulty that then presented itself in determining whether the true period of the Nile was 114 or 171 years. The Director of Egyptian Surveys has, however, since then supplied me with the heights of the Nile floods for 1906, 1907, 1908 and 1909, which have enabled me to extend the curve up to the latter year. It will now be seen that my deductions were correct, as the year 1907 proved to be the critical point of

change in the curve from dry to wet seasons, and there can hardly be any doubt but that *the curve from 1736 and following years is now being repeated from 1907 onwards*, thus demonstrating that the Nile's true period is 171 years.

British Rainfall.—The residual mass curve of British rainfall (*Plate 1*) is derived from the diagram (*Plate 2*, fig. 2) prepared by the late Mr. G. J. Symons, F.R.S., and referred to by him when discussing Sir Alexander Binnie's paper on "Average Annual Rainfall and the fluctuations to which it is subject."[1] Mr. Symons, whose whole life was devoted to the collection and study of rainfall statistics, was regarded as one of the highest authorities on the subject, as may be seen by the encomiums passed upon the results of his investigations, by those taking part in the discussion on Mr. H. R. Mills' paper on the "Distribution of Mean and Extreme Annual Rainfall over the British Isles."[2]

The diagram is a very remarkable one, extending from 1726 to 1890, covering a period of 165 years. It does not represent the rainfall at any single station, but the mean rainfall over the whole area of Britain, and on this account as might be expected, a difficulty presented itself owing to the paucity of information concerning the rainfall in the first part of the record. If the diagram be carefully studied, it becomes evident that the mean shown by Mr. Symons cannot be the true mean of the figures from which the diagram has been constructed. Instead of it being 100, as represented by him, I find the true arithmetical mean of the whole record to be 95, and this is the explanation of the very peculiar droop of the whole curve, when converted into one showing the residual mass. As the mean for the last 70 or 80 years obtained by Mr. Symons from a large number of well selected and reliable stations is no doubt closely approximate to the truth, I decided to adopt his

[1] Proceedings Inst. C.E., Vol. CIX, p. 89. [2] *Loc. cit.*, Vol. CLV, p. 293.

diagram[1] (*Plate 2*, fig. 2) as it stands, without attempting any alteration, and have accordingly taken out the rises and falls with reference to his mean of 100, and the curve comes out as you see in my diagram (*Plate 1*), shown by a thick black line.

The remarkable drought which commenced in the year 1738, when for 30 years there were only two years above the mean, namely, 1751 and 1763, and two just equal to the mean, namely, 1756 and 1764, the first 25 years having only one year above the mean pulled the curve rapidly down, and it never afterwards entirely recovered itself.

Another very remarkable thing is revealed by the curve, namely, that exactly 57 years after 1738, namely, in 1795, a second very pronounced long period of persistent decline commences, extending for twenty years to 1815, during which there were only two years above the mean, namely, 1797 and 1799. Again, after another 57 years from 1795, or in 1853, a third period of decline occurs, extending for nineteen years to 1871, with 6 years above the average, namely, 1860, 1862, 1865, 1866, 1868 and 1869, the first seven years making a very rapid fall. Concerning this drought I find that Mr. Glaisher, the then Registrar General of England, in his quarterly return for June 1859, made the following remarks:—

"The deficiency in the years 1854, 55, 56, 57 and 58 amount to the average fall of one year, namely, 25 inches. From a careful examination of the fall of rain from the year 1815 it will be seen that the annual fall is becoming smaller, *and that there is but little probability that this large deficiency will be made up by excesses in future years.*"

This is certainly a very remarkable statement, coming as it does from an officer in Mr. Glaisher's position, and it

[1] The black portion of the diagram represents the fluctuation of the rainfall as delineated by Mr. Symons, the hatched portions were done by me to show up the droughts I have referred to.—T.W.K.

goes a long way in my opinion to confirm the correctness of this portion of Mr. Symons' diagram.

It will be seen that in the year 1815 they were, in England, just at the termination of the second severe drought, shown on the diagram, which commenced in 1795, during which the loss of rain below the mean amounted to more than double the quantity mentioned by Mr. Glaisher as having been lost in the period from 1854 to 1858, and although something less than two-thirds of this loss had been made up by an accumulated rise in the rainfall to the year 1831, this rise was not maintained, as it will be seen that rains below the average were experienced in excess of those above it for twenty years up to the year 1851. One year of high rainfall then followed in 1852 (which year corresponds with that of 1909) to be followed by a long period of drought in which the accumulated loss of rain during nineteen years to 1871 pulled the curve down to its lowest point, there having been only six years above the average in the whole period.

Another important feature is conspicuous in the diagram, namely, the period between the termination of the two droughts in 1814 and 1871 is exactly 57 years.

With this evidence before them, and the fact that critical points of change are discernible in 1738, 1757, 1776, 1795, 1814, 1833, 1852, 1871, 1890, and 1909, the intervals between which are nineteen years, it is difficult to understand how meteorologists in England have not, up to the present time, noticed this peculiarity. If the residual mass curves had been worked up the phenomenon of secular variation would have been discovered long ago.

Mr. Symons, when referring to his diagram at the discussion on Sir Alexander Binnie's paper in 1892,[1] said:—

"I have exhibited the diagram in order that the members might form a rough idea of the amount of oscillation to which the annual total rainfall was liable. I will not enter into the question

[1] Proceedings Inst. C.E., Vol. cix, p. 139.

of the remarkable drought shown by that diagram. It was a matter over which meteorologists were very much perplexed, because, if during the years from 1738 to 1760 there really was only one year with the rainfall above the average, and if such a period returned, there was not a town nor city in the United Kingdom in which the supply of gravitation waterworks would not break down. The question was whether the returns upon which the diagram was based were, or were not, true. If they were true, what had happened once might happen again, and there might occur a period in which the supply would break down in all the works in the Kingdom. It would be observed that recently there were nine years in succession, in every one of which the rainfall was above the average, and that during the whole period of one hundred and seventy years there was no precedent for such a state of things. But as there had been such a tremendous excess in those years, it was reasonably probable that such a state of things might occur again. The object of the diagram, however, was to give a general idea of the amount of fluctuation to which the rainfall was subject."

Concerning the abnormal rainfall referred to by Mr. Symons, I have been to some trouble to ascertain whether this excessively wet period could be traced from the only reliable statistics available, namely, from the paper by Cornelius Walford, F.I.A., F.S.S., on "Famines of the World, Past and Present," read before the Statistical Society, 19th March.[1] I find at periods of exactly 171 years previous to the period mentioned by Mr. Symons, namely, from 1875 to 1883, as follows:—

1704 *England*—"Hottest and driest summer known for 20 years."

1705 *England*—"Very dry till end of August."

1705 *Europe*—"The temperature rose so high in Europe that it resembled that of a glass house furnace, and butchers' meat was baked in the sun, and from midday to 4 p.m. no one ventured out of doors."—*Eng. Mech.*, Vol. XXXIX, p. 506.

[1] Journal Statistical Society, Vol. XLI, 1878.

1705 *Europe*—"*Great rains and floods all over the Continent of Europe.*"

1705 *Ireland*—"Flood at Limerick : *Half Limerick drowned.*"

1707 *England*—"Great inundation at Dagenham, Essex, *continuing over several years.*" May.

1709 *England*—"Great frost for three months with snow, etc." "That dreadful winter" (White's Selbourne). Mr. Derham supposed that this frost was greater than any within the memory of man. (*Phil. Trans.*)

1709 *France*—"A severe famine throughout the Kingdom (no doubt caused by rain and cold, as in Scotland and England).

1709 *Scotland*—"Famine from *rain* and cold."

1709 *England*—"Famine from *rain* and cold."

1711 *England*—"Frost severe up to March."

1711 *Mobile, U.S.A.*—"City almost destroyed by inundations at the mouth of the Mobile River."

1711 *Camiola*—"Famine from *rains* and *mildew.* Continued several years."

There is evidence from the foregoing statements from a reliable source, to show that the period was an abnormally wet one, and is confirmation of the suspicion expressed by Mr. Symons that "What might happen once might happen again." Unfortunately the records are very meagre, if we go back further into the past, but following extracts from Mr. Walford's tables will, no doubt, be of interest in this connection :—

Wet period three cycles of 171 years back from 1875 – 1883
1362 – 1370

1365 *England*—"*Violent rain storms.*"

1369 *England*—"Great pestilence among men and larger animals followed by *inundations and extensive destruction of grain.*"

Wet period four cycles of 171 years back from 1875 – 1883
1191 – 1199

1193 to 1196 *England and France*—"Famine *occasioned by incessant rains.* The common people *(vulgus pauperum)* perished everywhere for lack of food, and on the footsteps of famine the fiercest pestilence followed in the form of acute fever."

1196 *England*—"Great floods in March *from rains.*"
1199 *England*—"Serious floods *from rains.*"

Wet period five cycles of 171 years back from 1875 – 1883
1020 – 1028
1025 *England*—"Famine from *rains* and plague."

Wet period six cycles of 171 years back from 1875 – 1883
849 – 857
856 *England*—"Great *rains* and floods followed by an *epidemic of quinsy.*"

Wet period eight cycles back from 1875 – 1883
507 – 515
515 *Britain*—"Most afflictive famine."

Sufficient has been said to show that at intervals of 171 years, or multiples thereof, the abnormal wet period from 1875 to 1883, as shown in the diagram, has been repeated, and it would appear that about 26 or 27 years after the termination of these rains a period of serious decline commences, as shown by the British rainfall curve. Mr. Walford's tables of famines, droughts, and frosts prove this conclusively. The evidence is, however, so voluminous that I have prepared the tables to form an appendix to this paper.

Concerning the decline in the British rainfall mentioned above, if the Nile curve be compared with it, it will be seen that during the period of 30 years onwards from 1738, while the Nile shows a steady, persistent rise, resulting from the rains on the Abyssinian tableland being almost continually in excess of the mean, (and it should be remembered that this fact has been confirmed by several explorers, as stated by Captain Lyons, there being only seven years out of thirty years below the mean), the British rainfall curve shows an equally persistent, but much more rapid, fall, owing to the rainfall over Britain during the same period being practically all below the mean, there being

only one year (1751) in the first 25 years above the mean, and one (1763) in the next five years above it. Twenty-eight years out of thirty years below the mean! We have seen, in the case of the British rainfall curve, this peculiar feature of declining rainfall repeated three times at regular intervals of 57 years. After the year 1909, which is three times 57, or 171 years after 1738, if the periodicity is to be maintained, the decline above referred to should commence to be repeated. The question is with what intensity, as the curve shows that it varies, being greatest after 1738, less after 1795, and least after 1852.

We shall not be long in doubt, however, for the behaviour of the Nile curve should afford a true indication of what may be expected in England and elsewhere. Unfortunately, I have no information at present to enable me to trace the Nile curve beyond 1905. If it should be found to be falling still, we may reasonably expect a repetition of the meteorological conditions at each place, similar to those indicated by the curves after the year 1795. On the other hand, should the Nile curve be rising steadily, then we may anticipate with a fair degree of probability that the meteorological conditions which existed after the year 1738 will be repeated, in which case there may be a most serious decline of British rainfall for 25 or 30 years; while the Nile will indicate abundant rainfall over the Abyssinian plateau during exactly the same period.

NOTE.—This was written before I had received the information concerning the behaviour of the Nile subsequent to the year 1905. It will now be seen from the diagram that the Nile's curve since 1907 is on a strong upward gradient, similar to that shown after the year 1736, and *we may therefore reasonably anticipate that the very serious decline shown in the British rainfall curve will be repeated, and should commence in the present year 1910.*

Padua Rainfall Curve.—The rainfall curve at Padua is shown by dotted line, and has been constructed from the figures given by Sir Alexander Binnie in his paper on "Average rainfall" before referred to. Taken in conjunction with the British curve, it is useful to show the character of the weather on the Continent of Europe. The curve ends in 1821 after a rapid decline for nine years. It is unfortunate that information is not forthcoming to show how much longer this drought lasted, as history shows that very great heat and drought prevailed in Europe for at least three years more. The record at Padua is considered to be one of the longest in the world, and it is understood to be continuous up to the present time; it would, therefore, be very desirable to obtain the necessary particulars to enable the curve to be completed.

To show the character of the drought in the period above mentioned from 1813 to 1824, and in the series at 171 year intervals from it, the following extracts from "Historical Events" will be interesting:—

1818 "Great drought in Germany. All vegetation parched up and even the rivers dried up."

1822 "Intense heat in Italy and Europe accompanied by hurricanes and earthquakes."

1303, 1304, 1305 "Protracted drought in Europe, insomuch that the largest rivers of Europe, the Rhine, the Seine, the Po, and the Tiber, all shrunk to the tiniest streamlets."

1132 "In Europe the earth was so parched with intense solar heat that great fissures were made in it for miles."

1135 "Great drought in France and England."

1139 "Similar conditions to those in 1132, the heat being so intense that great fissures extended for miles in the earth, especially in Italy.

968 "Severe famine in Germany."

627 "The water supply of France, Germany and Italy entirely dried up."

It will be seen that heat was the predominant feature of this series, and this was followed by storms, with heavy rains and floods. The winters were very cold, the rivers being sometimes frozen.

I have prepared tables of historical events, as complete as it has been possible to make them, during the three periods 1756 to 1767, 1813 to 1824, and 1870 to 1881 (which are at 57 year intervals) and at 171 year intervals from each of the periods back into the past. These tables afford a means of comparison, but are too voluminous to be printed with this paper. They are, however, available to anyone desiring to satisfy himself that the conditions are similar, as I have stated, although varying in intensity.

In the first series, commencing from 1756 to 1767, it will be seen that it is remarkable for the intense cold of the winters. In the second series, commencing from 1813 to 1824, the great heat of the summers is noticeable as already referred to; while in the third series, commencing from 1870 to 1881, the intensity and violence of the storms with excessive rain, causing high floods, are the prominent features.

Similar tables have been prepared for the periods 1776 to 1785, 1833 to 1842, and 1890 to 1899 (which are also at 57 year intervals), and at 171 year intervals therefrom. These will be found to be extremely interesting, as they show the character of the weather at the critical points of change in the Nile's curve, viz.: at 1782, 1839, and 1896.

Drought and Famine in India.—In default of any reliable rainfall statistics extending over a period sufficiently long to enable a residual mass curve to be constructed which might fairly be compared with other long records available, I have considered it advisable to show the years of drought and famine, which have been collected from reliable sources, in their proper places on the diagram by means of black

dots. Famine occurs so frequently in India, sometimes from other causes than drought, and as history unfortunately has not kept a regular account of either, it is difficult to arrive at any very satisfactory conclusions with reference to periodicity from the records available. Sufficient information, however, exists to show that there is a tendency for drought and famine to recur in accordance with 57 year periods, with varying intensity.

For example: One of the most severe droughts which has ever been experienced occurred from 1873 to 1878, the greatest intensity being from 1875 to 1877, when from 250,000 to 300,000 square miles were affected with famine. A similar drought, lasting six years, occurred with the greatest intensity in the years 1020, 1021, and 1022; the interval between these two great droughts being 855 years or five cycles of 171 years. From the diagram it will be seen that droughts in the series of 57 years occurred in 1762 and again in 1819 – 1820.

Another great drought is shown to have occurred from 1745 to 1753, and was repeated with less intensity from 1802 to 1807, and with more intensity from 1859 to 1870, with a break in 1863-1864. History shows that a drought in this series occurred in 1291, being 513 years before 1804, and again in 1412-1413, being 342 years before 1754-1755.

The drought which is shown to have taken place from 1780 to 1784 was repeated with less intensity from 1837 to 1839, and with greater intensity from 1896 to 1901.

A drought, which will no doubt be of interest at the present time, is recorded in Dow's "Hindustan." It is reported to have occurred at Ghor (on the borders of India and Afghanistan) from 1052 to 1060:—"So that the earth was burned up, and thousands of men and animals perished of heat and famine." Although there is no mention of drought having occurred in India in this series from 1736

to 1744, excepting 1739, or from 1793 to 1801, it is not at all certain that such dry conditions did not exist at those times, especially in view of the fact that in the next 57 years period Mr. Danvers reports drought, and scarcity increasing to drought with famine in 1853, 1854, 1856, 1857, 1858, 1859, 1860, 1861 and 1862. This drought appears to have commenced in 1852, gradually increasing in intensity until in 1859-60, "The Delhi Territory suffered greatly from want of rain. *The great Nujjufghur Jheel became entirely dry, a thing never before known within the memory of man.* The rains of 1860 also completely failed in the country between the Jumna and the Sutlej, and except where irrigation was available, no autumn or spring crops could be sown."

We have not yet heard of drought having commenced in India, but as we have now entered upon a period in this series when the greatest intensity of drought may be looked for, namely, from the present year, 1910 to 1916-17, it will, therefore, be interesting to watch for developments in India.

Earthquakes.—So much work has already been done by many eminent men to determine whether periodicity could be traced in the occurrence of earthquakes, and the result of their investigations has been such as to lead one to expect very little help in the endeavour to show some connection between these phenomena and the changes in the weather, that I must confess I thought it would be useless for a layman to enter upon so great a question, when the best equipped investigators had failed to arrive at any satisfactory results.

After I had plotted the Nile's curve, however, and had discovered the critical points of change in it at 1736, 1782, 1839, 1896, and 1907, as already described, on comparing those dates with a catalogue of earthquakes, I found that at those critical points the greatest earthquakes occurred. For instance, in 1906, 1907, the great earthquakes of San

Francisco and Messina took place, which are still fresh in our memories.

In 1895, 1896, 1897 three of the greatest earthquakes of which there is any record occurred, namely, in 1895 at Sumatra, which is said to have been nearly as powerful as the Bengal Assam earthquake in 1897. In 1896 the great Japanese earthquake with its enormous tidal waves occurred. In 1897 the great Bengal-Assam earthquake, which Hutton describes as being "the most powerful and widespread of which we have any record, not excepting even the memorable event of Lisbon in 1755. The shocks were felt over 1,750,000 square miles."

In 1838, 1839, 1840 a succession of violent earthquakes occurred, namely, in 1838 in Transylvania, and parts of Turkey and Russia, the shocks lasting a minute and thirteen seconds, Etna and Vesuvius were subsequently in eruption. In 1839 violent earthquakes occurred in the Island of Martinique, lasting two minutes, and also in other islands in the West Indies, doing immense damage; also at Guatemala and Burmese Empire, the former being very violent and destructive, and the latter extending over 1,000 miles from north to south. In 1840 there were a great number of exceedingly violent earthquakes of which the principal appear to have been in the island of Ternate, preceded by a volcanic eruption. In Upper Assam the earthquakes were preceded by a total eclipse of the sun. In Burmah they were very violent and destructive, culminating in a series of violent earthquakes throughout the whole district of Ararat in Armenia, extending from June 20th to August 2nd. It is reported that the whole aspect of the country was changed by these formidable earthquakes, and enormous destruction and loss of life occurred.

In 1781, 1782, 1783 tremendous seismic disturbance was felt. It is recorded that in 1781 "such numerous earth-

quakes occurred in Italy that the Pope ordered public prayers to be offered for their cessation."

In 1782 in the Abruzzo they were very violent, the walls being shaken to their foundations. In Hungary "a chasm opened, and 53 houses were swallowed up." Earthquakes occurred in the Pyrenees, Rome, and again in Hungary. These serious earthquakes culminated in February 1783 at Calabria and Sicily in "one of the most disastrous earthquakes ever felt in Europe." All the towns and villages throughout the Plain of Calabria and Sicily were shaken with tremendous violence, and the devastation was awful." Great sea waves occurred in the straits of Messina; mountains fell, and rivers stopped. At Messina the quay sank, etc. Earthquakes of exceeding violence also occurred at the island of Amboyna, at Lisbon, Iceland and Japan, which lasted four or five days with great destruction and loss of life. Also at Thessalonica, where mountains fell, and the shocks were considered to be more destructive than those at Messina. Finally at Guatemala terrible shocks were experienced.

In 1735, 1736, 1737, the records show that great earthquakes and volcanic disturbances occurred, not exactly at the *same places* as in 1906, 1907, and 1908, but places lying in or about the *same latitude* were affected. For instance, in 1735, in October, Etna was in eruption. Repeated shocks were felt over an area of 30 miles round. The eruption continued until July of 1736.

In 1736 a very violent earthquake occurred all along the northern part of Sicily, especially at Ciminna, Palermo, and Naso. Also in the island of Cyprus, and the island of Cephalonia, where great damage was done on the northern part of the island.

In 1737 an extremely violent eruption of Vesuvius occurred, which lasted from 14th to 23rd May. Earth-

quakes occurred at Smyrna, Greece, Boston (United States) and Constantinople. At Kamtschatka and the Kurile Islands there was an extremely violent earthquake. The sea was greatly agitated, overflowed the land to an extraordinary height, and then retired so far that the bottom was visible between the first and second of the Kurile Islands, followed by an eruption of a volcano there. Great changes were produced by this earthquake on the surface of the country. Many level places were raised into hills, and others sunk into chasms. Near the sea, lakes and bays were produced.

At nineteen year intervals from these critical points in the Nile's curve, it will be found that similar violent earthquakes have occurred, and the tendency appears to be along or near the same latitudes, if not at the same places. It would be interesting to quote examples in proof of my statements, but space will not permit of this being done. I have, however, prepared complete lists with the latitudes of the places where earthquakes have occurred, and these can be seen by anyone interested in the matter.

Halley's Comet.—As this comet will make its appearance in May this year (1910), I thought it might be interesting to show its position on the diagram, as far back as information is available. The dates have been obtained from the "Encyc. Brit." to the year 1456, and those visitations which occurred previously to that year, from Hind's "Past History of the Comet Halley."[1] The positions of the comet on the diagram depend upon the assumption of 171 years' periodicity for the Nile's curve.

The disturbance of the comet's period of revolution from time to time, through planetary perturbations, has spread the positions of its visitation pretty well all over the diagram, from which it would appear that, if the earth's

[1] Monthly Notices Royal Astronomical Society, vol. x.

atmosphere be affected by the comet at the times of its perihelion in such a manner as to produce abnormal droughts or floods, it is certainly not discernible in the Nile's curve. It is, however, worthy of note that, notwithstanding that the comet's period of revolution since the year B.C. 11 has not been regular, the range being from about 75 years to about 79 years, it would appear to be in some mysterious way subject to the same cosmical law which not only causes the remarkable changes in the character of the weather at nineteen year intervals, but the occurrence of earthquakes of greatest intensity at the same places, or along the same parallels of latitude, is particularly noticeable at the critical points of change in the Nile's curve, and at nineteen year intervals from those points. To prove this, if we take the intervals between the following appearances of Halley's comet, it will be seen that they are all multiples of nineteen years:—

Date of Comet's appearance.	Interval in years.	Date of Comet's appearance.	Interval in years.	Date of Comet's appearance.	Interval in years.
B.C. 11 A.D. 65	76	608 684	76	1378 1910	532
B.C. 11 A.D. 141	152	608 760	152	1531 1607	76
A.D. 65 „ 141	76	608 912	304	1531 1759	228
„ 218 „ 1301	1083	684 760	76	1531 1835	304
„ 295 „ 1378	1083	684 912	228	1607 1759	152
„ 295 „ 1682	1387	760 912	152	1607 1835	228
„ 295 „ 1910	1615	837 989	152	1682 1910	228
„ 373 „ 1456	1083	1378 1682	304	1759 1835	76

Drought in Egypt.—On an inspection of the Nile curve, it will be seen that there have been periods when the annual inundation was below the mean for a considerable number of years in succession, denoting drought of more or less intensity, yet modern history has very little to say about them. Reference is made[1] to a drought in A.D. 1201. Although only one year is mentioned, it is probable that it was of greater duration, and that the year 1201 was near the end of the drought, when its effects would be more severely felt. This drought no doubt occurred four cycles of 171 years before 1885, when it will be seen that the Nile had been below the average for six years in succession with the exception of 1883.

It is stated[2] that for seven years (A.H. 457 – 464) = A.D. 1064 – 1070, the annual inundation failed. This was four cycles of 171 years before 1748 – 1751. The curve shows that in this period the Nile was low in 1748 and 1749, and again in 1751, three years out of the seven. It is possible, therefore, that the Nile may be subject to a variation in intensity at this period. This drought might have occurred either 13 cycles of 57 years before 1805 - 1811, or 14 cycles of 57 years before 1862 – 1868. It will be seen in the latter period the Nile was low for five years out of the seven. With the information we now possess concerning the state of the Nile during one complete cycle of 171 years, it will, no doubt, be interesting to turn to the Bible to ascertain whether the dates given by the chronologists (Bishop Ussher and others) in the margins of the authorised version of the English Bible agree with those showing drought in the Nile's curve on my diagram, on the assumption of 171 years' periodicity. It will be seen that they do so in almost every instance in a very remarkable manner. It will be remembered that Mr. Russell was severely criticised

[1] "Modern Egypt," p. 115. [2] Encyc. Brit., vol. XII, p. 706.

because he drew attention to the fact that the intervals between these droughts and ours are multiples of nineteen years, and that the intervals amongst them are either exactly nineteen years or multiples of nineteen years. Had Mr. Russell been in possession of the information which is now before you, he would have been in a better position to demonstrate the fact that the dates given by the chronologists could not have been mere guesses, but the result of painstaking, marvellously accurate work. The droughts referred to were as follows:—

Abraham's Drought.—If Genesis XI, 31, XII, 1 to 20, XIII, 1 to 18 be studied, it will be seen from the text and marginal dates, that Abraham was living in the land of Canaan in B.C. 1923 = 22 cycles of 171 years before A.D. 1839, at which time a fearful drought prevailed over all that region. He, therefore, moved into the land of Egypt, where it will be seen from the diagram, good seasons were experienced in B.C. 1922, 1921, and 1920, (A.D. 1840, 1841, 1842).

Drought, however, returned in Egypt, and Abraham, in B.C. 1918 (XIII, 1) moved out of it, and returned again to Canaan, where in B.C. 1917 (XIII, 12) he was dwelling at a time when the land was well watered (XIII, 10) "Even as the garden of the Lord like the land of Egypt."

On reference to the diagram it will be seen that B.C. 1917 corresponds with A.D. 1845, in which year the drought terminated and a long succession of good seasons commenced.

Isaac's Drought.—Genesis XXVI, 1. "And there was a famine in the land beside the first famine that was in the days of Abraham. And Isaac went unto Abimelech, King of the Philistines unto Gerar."

The marginal date is B.C. 1804, or two cycles of 57 years =114 years after Abraham found it necessary to leave Egypt on account of the drought there (see XIII, 1). The

drought at Gerar in B.C. 1804 is 21 cycles of 171 years before A.D. 1787. A glance at the diagram will show the character of the drought which is one of the most serious and prolonged in the whole record of the Nile. It had already lasted seven years, and continued for ten years more without a break above the average. It is plain, therefore, that Egypt was a place to keep out of, and accordingly we find in XXVI, 2:—

"And the Lord appeared unto him and said, 'Go not down into Egypt, dwell in the land which I shall tell thee of.'" (6) "And Isaac dwelt in Gerar."

No doubt the drought was there also, although probably not so severe as in Egypt, for in (12) it is recorded that he sowed in that land and received in the same year an hundredfold. It is evident, however, that dependence had to be placed upon wells, several of which were sunk in the place formerly occupied by Abraham (see 15 to 22). Being driven away from there by the herdsmen of Gerar, who claimed the wells, he ultimately settled at Beersheba, where he sank a well, and found permanent water (XXVI, 32), which, no doubt, enabled him to exist during the extremely dry period, denoted by the long and very persistent fall in the Nile curve shown on the diagram.

Pharoah's Drought.—Genesis XLI, 46. "And Joseph went out from the presence of Pharoah and went throughout all the land of Egypt."

Marginal date B.C. 1715, years of plenty commenced.

(47) "And in the seven plenteous years the earth brought forth by handfuls."

(48) "And he gathered up all the food of the seven years which were in the land of Egypt and laid up the food in the cities."

Marginal date B.C. 1708.

(53) "And the seven years of plenteousness that was in the land of Egypt were ended."

(54) "And the seven years of dearth began to come according as Joseph had said and the dearth was in all lands, but in all the land of Egypt there was bread.'

This drought, which was repeated in A.D. 1201 (see page 62) *occurred 95 years (=5 × 19) after that of Isaac in* B.C. 1804, and is 21 cycles of 171 years before A.D. 1883. It will be seen from the diagram that from A.D. 1869 to A.D. 1879 there were nine splendid seasons in succession on the Nile, broken only by two bad years, viz., A.D. 1873 and 1877, which were much below the average. The dry seasons commenced in A.D. 1880, the drought gradually increasing in intensity until in A.D. 1883 (B.C. 1708) after three years of drought, the famine had spread all over the land of Egypt, but the grain having been stored in all the cities during the years of plenty, as directed by Joseph (see XLI, 48, 49), the people were saved from starvation.

The drought continued to A.D. 1889 (B.C. 1702). Good seasons commencing in A.D. 1890 (B.C. 1701) extending to A.D. 1896 (B.C. 1695), when a more severe drought than the one already experienced, commenced in the following year. It is strange that no mention is made of this in the Bible; but no doubt Joseph (who would, from his official position under Pharoah, have access to the Nilometer records) was aware of the impending drought, and made provision for it, as he had previously done. The method he adopted is fully described in XLVII, 13 to 26, wherein it is stated that, the people being destitute, he bought up all the land of Egypt for Pharoah, and established food depôts in the various cities in which the grain was stored. Seed was distributed to the people on the understanding that "in the increase one-fifth part shall be given to Pharoah," the remaining four-fifths to be retained by them for their subsistence.

This does not appear to have been merely a tentative measure, for, in (26) it is stated:—

"And Joseph made it a law over the land of Egypt unto this day, that Pharoah should have the fifth part; except the land of the priests only, which became not Pharoah's."

Under this system, the people being merely tenants of the Pharoah, paying the annual tax of one-fifth part of their increase, it was not difficult for a wise and beneficient ruler, as this Pharoah appears to have been, acting under the guidance of a trusted official, who had evidently acquired exact knowledge of the time and duration of dry and wet seasons, to make such provision as to enable a dense population to exist, during the long periods of drought which we now know must have occurred in the past. Let us, therefore, hope that the exact knowledge which Joseph undoubtedly possessed of the periodicity of weather, from a close study of the Nile records, has at last been restored to us after a lapse of over 3,600 years, and that we shall be enabled to similarly forecast the seasons, and make as wise provision as he did, during the years of plenty against the years of drought, which have so long afflicted us, but whose alternating periods have, up to the present time, been as illusive as a will-o-the-wisp.

David's Drought.—II Samuel XXI, 1. "Then there was a famine in the days of David three years, year after year; and David enquired of the Lord. . . ."

The marginal date is B.C. 1021, which is 684 years, or four cycles of 171 years, after B.C. 1705, the fourth year of the famine of Pharoah and Joseph, or seventeen cycles of 171 years before A.D. 1886. The diagram shows that there was a drought on the Nile in A.D. 1886 and two previous years, and no doubt Palestine, in which David was living, was similarly affected.

Elijah's Drought.—[Marginal date B.C. 910.] I Kings XVII, 1. "And Elijah the Tishbite, who was of the inhabitants of Gilead, said unto Ahab, as the Lord God of Israel liveth, before whom I stand, there shall not be dew nor rain these years, but according to my word."

(7) "And it came to pass after a while, that the brook dried up, because there had been no rain in the land."

I Kings xviii, 1. "And it came to pass after many days, that the word of the Lord came to Elijah in the third year, saying, Go show thyself unto Ahab, and I will send rain upon the earth."

(2) "And Elijah went to show himself unto Ahab. And there was a sore famine in Samaria."

(41) "And Elijah said unto Ahab, 'Get thee up, eat and drink, for there is a sound of abundance of rain."

[Marginal date B.C. 906.] (45) "And it came to pass in the meanwhile, that the heaven was black with clouds and wind, and there was a great rain."

This drought is fourteen cycles of 57 years after Pharoah's in B.C. 1708. Its place on the diagram will be seen to be sixteen cycles of 171 years before A.D. 1826, when the drought commenced in B.C. 910, and extended to B.C. 906 = A.D. 1830.

The drought occurred in Samaria at the same time as drought existed on the Nile.

The termination of the drought was marked by the great rain mentioned in I Kings xviii, 45, which does not appear in the Nile curve at this place, but there is a tendency for heavy rain to occur at this period as shown by the break in the drought in A.D. 1887 (see Nile's curve), a peculiarity which is seen in the Lake George curve at the same date, as well as all other stations in Australia. It is also noticeable in the Padua curve in A.D. 1773. It is, therefore, highly probable that this rain was experienced in Palestine at the date given, namely, B.C. 906.

Elisha's Drought.—[Marginal date B.C. 891.] II Kings viii, 1. "Then spake Elisha unto the woman, whose son he had restored to life, saying, 'Arise, and go thou and thine household, and sojourn wheresoever thou canst sojourn; for the Lord hath called for a famine; and it shall come upon the land seven years."

(2) "And the woman arose, and did after the saying of the man of God; and she went with her household, and sojourned in the land of the Philistines seven years."

[Marginal date B.C. 885.] (3) "And it came to pass at the seven years' end, that the woman returned out of the land of the Philistines; and she went forth to cry unto the King for her house and for her land."

This drought occurred in Samaria, the marginal dates B.C. 891 and B.C. 885 fix the time of its beginning and end very clearly. It will be seen to have occurred exactly nineteen years after Elijah's drought in B.C. 910, and is sixteen cycles of 171 years before A.D. 1845. The diagram shows that the Nile curve, after reaching a low point in the trough of the curve in A.D. 1845, was on an upward gradient to A.D. 1851, which denotes good seasons in Egypt, owing to the Nile being above the mean, excepting 1850, while drought existed in Samaria.

It will be noticed that Dr. Livingstone experienced drought in South Africa during this period, when there were good rains above the average on the Abyssinian plateau, which were responsible for the continued rise of the Nile. Chonuane in South Africa, where Dr. Livingstone's drought occurred, is in about the same distance south of Abyssinia that Samaria is north of it, so it is quite probable that similar meteorological conditions would exist at the two places at the same time, seeing that Abyssinia is close to the equator.

The year A.D. 1845, (which is 57 years before A.D. 1902 when intense drought was experienced almost everywhere in the southern hemisphere) was evidently a critical one, as may be realised on comparing its position on the diagram with the curves of Adelaide, Horsham, Sydney, etc, and also the Nile.

The long drought and desolation described by the Prophets Jeremiah and Ezekiel, commencing in B.C. 612, and ending B.C. 549 :—

The most remarkable confirmation of the truth of the Nile curve as shown in the diagram, and the proof that its

period is one of 171 years, is given by the description of the drought and desolation which occurred in Palestine and Egypt, from B.C. 612 to B.C. 549, by the Prophets Jeremiah and Ezekiel. With regard to the correctness of the dates given in the margins of the authorised version of the English Bible, it is gratifying to know that by recent investigations, the dates (which are ascribed to Bishop Usher)[1] up to 732—33 B.C. have been confirmed by the testimony of the monuments in Babylonia, Assyria, and Egypt.[2]

The drought and desolation, which was to come upon the people of Israel, was foretold by Jeremiah in B.C. 629 or 17 years before it commenced. When the drought began in the year B.C. 612 which is 14 cycles of 171 years, before A.D. 1782, the fact was made known that—

"A dry wind of the high places in the wilderness" had set in. (Jer. IV, 11). "Therefore the showers have been withholden, and there hath been no latter rain." (Jer. III, 3). "The lion is come from his thicket, and the destroyer of the Gentiles is on his way, he is gone forth from his place to make thy land desolate; and thy cities shall be laid waste, without an inhabitant" (Jer. IV, 7). "Destruction upon destruction is cried; for the whole land is spoiled." (Jer. IV, 20).

Some of the above references relate to the ravages about to be made by the enemy "out of the north," but the following beautiful verses portend the long drought then just commencing, and clearly indicate the cosmic origin of the phenomenon (Jer. IV, 23 to 28) B.C. 612 :—

"I beheld the earth, and lo! it was without form, and void; and the heavens, and they had no light.

"I beheld the mountains, and lo! they trembled, and all the hills moved lightly.

"I beheld, and lo! there was no man, and all the birds of the heavens were fled.

[1] Encyc. Brit., vol. XXIV, p. 17. [2] *Loc. cit.*, XXVII, p. 77.

"I beheld, and lo! the fruitful place was a wilderness, and all the cities thereof were broken down at the presence of the Lord, and by his fierce anger.

"For thus hath the Lord said, the whole land shall be desolate; yet will I not make a full end.

"For this shall the earth mourn, and the heavens above be black; because I have spoken it, I have purposed it, and will not repent, neither will I turn back from it." (Jer. IV, 23 – 28) B C. 612. See also Jer, V, 18, 24, 25; VI, 8.

The progress of the drought is referred to in Jer. XII, 4. B.C. 608.

"How long shall the land mourn, and the herbs of every field wither."

A desolation for 70 years is predicted in B.C. 606 ending B.C. 536, See Jer. XXV, 8 to 12.

At the same time the restoration of Israel in B.C. 536 is referred to in XXX, 3, XXXI, 5:—

"Thou shalt yet plant vines upon the mountains of Samaria; the planters shall plant, and eat them as common things."

The progress of the drought is again touched upon in B.C. 605. Jer. XVIII, 21; B.C. 602, Jer. XIII, 20; B.C. 601, Jer. XIV, 1:—

"The word of the Lord that came to Jeremiah *concerning the dearth.*

"2. Judah mourneth, and the gates thereof languish; they are black unto the ground; and the cry of Jerusalem is gone up.

"3. And their nobles have sent their little ones to the waters; they came to the pits, and found no water; they returned with their vessels empty; they were ashamed and confounded, and covered their heads.

"4. Because the ground is chapt, for there was no rain in the earth, the plowmen were ashamed, they covered their heads.

"5. Yea, the hind also calved in the field, and forsook it, because there was no grass.

"6. And the wild asses did stand in the high places, they snuffed up the wind like dragons; their eyes did fail, because there was no grass." See also 15, 18, 22.

B.C. 600, Jer. VIII, 13. "There shall be no grapes on the vine, nor figs on the figtree, and the leaf shall fade; and all things that I have given them shall pass away from them."

Also B.C. 600, Jer. VII, 20, 32, 33, 34. B.C. 600 (see IX, 10 to 16. B.C. 599, XXIX, 10, 17, 18. B.C. 590, XXXVIII, 2. B.C. 588, XL, 3.

B.C. 588, XLII, 10 to 12. The people of Israel are cautioned to remain in Judea and not to go into the land of Egypt. In 13 to 22, the doom that awaits them in Egypt is described:

"So it shall be with all men that set their faces to go into Egypt to sojourn there; they shall die by the sword, by the famine, and by the pestilence; and none of them shall remain or eacape from the evil that I will bring upon them."

Jer. XLIII, 5, 6, 7, show that, notwithstanding the caution the people went into Egypt, B.C. 588. The punishment for disobedience is set forth in XLIV, 11 to 13, B.C. 587:—

"They shall all be consumed, and fall in the land of Egypt; they shall even be consumed by the sword and by the famine; they shall die, from the least even unto the greatest, by the sword and by the famine." See also 22, 27, 28.

B.C. 589, Ezekiel XXIX, 1 to 7. "Son of man, set thy face against Pharoah King of Egypt, and prophesy against him, and against all Egypt. Speak, and say, Thus saith the Lord God; Behold I am against thee, Pharoah King of Egypt, the great dragon that lieth in the midst of his rivers, which hath said, my river is mine own, and I have made it for myself."

B.C. 589. Prediction of drought and desolation for a further term of 40 years ending in B.C. 549.

Ezekiel XXIX, 8. "Therefore thus saith the Lord God, Behold, I will bring a sword upon thee, and cut off man and beast out of thee.

"9. "And the land of Egypt shall be desolate and waste; and they shall know that I am the Lord; because he hath said, The river is mine, and I have made it.

"10. Behold, therefore, I am against thee, and against thy rivers, and I will make the land of Egypt utterly waste and desolate, from the tower of Syene even unto the borders of Ethiopia.

"11. No foot of man shall pass through it, nor foot of beast shall pass through it, neither shall it be inhabited *forty years.*

"12. And I will make the land of Egypt desolate, in the midst of the countries that are desolate, and her cities among the cities that are laid waste shall be desolate forty years; and I will scatter the Egyptians among the nations, and will disperse them through the countries.

"13. Yet thus saith the Lord God: At the end of forty years will I gather the Egyptians from the people whither they were scattered.

"14. And I will bring again the captivity of Egypt, and will cause them to return into the land of Pathros, into the land of their habitation, and they shall be there a base kingdom.

"15. It shall be the basest of the kingdoms, neither shall it exalt itself any more among the nations; for I will diminish them that they shall no more rule over the nations"

B.C. 587, Ezekiel XXXII, 13. "I will destroy also all the beasts thereof beside the great waters; neither shall the foot of man trouble them any more, nor the hoofs of beasts trouble them.

"14. Then will I make their waters deep, and cause their rivers to run like oil, saith the Lord God."

"15. When I shall make the land of Egypt desolate, and the country shall be destitute of that whereof it was full, when I shall smite all them that dwell therein, then shall they know that I am the Lord."

Drought is clearly indicated, so that the reference to the *deep* waters running like *oil* must mean that the Nile would

remain low, and the waters sluggish and stagnant. The translation should probably have been "Then will I make their deep waters to run like oil." The restoration of Israel to their own land when the drought shall have ended, and good seasons returned, is described in Ezekiel XXXIV. B.C. 587:—

"13. And I will bring them out from the people, and gather them from the countries, and will bring them to their own land, and feed them upon the mountains of Israel by the rivers, and in all inhabited places of the country.

"14. I will feed them in a good pasture, and upon the high mountaims of Israel shall their fold be; there they shall be in a good fold, and in a fat pasture shall they feed upon the mountains of Israel."

"26. And I will make them, and the places round about my hill, a blessing; and I will cause the shower to come down in his season; there shall be showers of blessing.

"27. And the tree of the field shall yield her fruit, and the earth shall yield her increase, and they shall be safe in their land."

Reference is made again to the restoration after the period of drought and desolation shall have ended.

Ezekiel XXXVI, 8, B.C. 587. "But ye, Oh mountains of Israel, ye shall shoot forth your branches, and yield your fruit to my people of Israel, for they are at hand to come.

"9. For, behold, I am for you, and I will turn unto you, and ye shall be tilled and sown.

"10. And I will multiply men upon you, all the house of Israel, even all of it; and the cities shall be inhabited, and the wastes shall be builded.

"11. And I will multiply upon you man and beast; and they shall increase and bring fruit; and I will settle you after your old estates, and will do better unto you than at your beginnings.

"34. And the desolate land shall be tilled, whereas it lay desolate in the sight of all that passed by.

"35. And they shall say, This land that was desolate is become like the garden of Eden; and the waste and desolate and ruined cities are become fenced, and are inhabited.

B.C. 587 Ezekiel XXXVII, 1—14. The description of the valley that was full of dry bones which were restored to life, is typical of the restoration of the land and its inhabitants, which had been desolated and destroyed by drought and famine.

B.C. 572. Ezekiel XXX. The desolation of Egypt is again referred to, and mention is made again of the drought in (12).

"And I will make the rivers dry, and sell the land into the hand of the wicked; and I will make the land waste, and all that is therein, by the hand of strangers."

On looking at the diagram, and remembering what has already been said about the accuracy of the Biblical dates covering the period of this drought, I think it will be admitted that there are very good reasons for believing, that the very long period during which the Nile was almost continually below the average, denoting a protracted drought over the Abyssinian table land, from 1782 to 1845, was actually a recurrence of the drought which was experienced in the days of Jeremiah and Ezekiel, namely, from B.C. 612 to B.C. 549. The interval of time, 1782 + 612 = 2394 years, is exactly 14 cycles of 171 years. Although there is nothing in either of the books of the Prophets to show the actual fulfilment of the prediction, that the drought would terminate 40 years after B.C. 589, or in B.C. 549, a study of the diagram will leave little doubt, but that Ezekiel's prophecy was verified, if there is any truth in periodicity.

It will now be interesting to note that the following droughts occurred in this particular part of the Nile's curve. B.C. 612 to B.C. 549 = A.D. 1782 to A.D. 1845. Isaac's drought in B.C. 1804 or seven cycles before B.C.

607, when the drought had lasted six years. Elijah's drought in B.C. 910 – 906, or two cycles before B.C. 568 – 564. Elisha's drought in B.C. 891 – 885 or two cycles before B.C. 549 – 543. Abraham's drought in B.C. 1920 or eight cycles before B.C. 552.

Mention should also be made of the fact of the fulfilment of the promise made in Jeremiah XXX, 3; XXXI, 5, 6, that after seventy years (B.C. 606 – 536) of desolation and captivity (XXV, 8 – 12) were accomplished the Jews would return to the land of their fathers in Palestine. See Daniel IX, B.C. 538, and Ezra I, II, B.C. 536, in which the restoration to Jerusalem is clearly set forth.

The chronological investigation in the light of the testimony of the monuments in Babylonia, Assyria and Egypt, already referred to,[1] establishes the accuracy of Usher's dates for this particular period, as follows:—

Monumental Date.		Usher's Date.
B.C. 621.	Discovery of the book of the law (Deuteronomy) in Josiah's 18th year (II Kings, XXIII, f.f.).	B C. 624
B.C. 597.	Jehoichin (3 mo). First deportation of captives (including Jehoichin) to Babylonia in the 8th year of Nebuchadnezzar (II Kings, XXIV, 12 – 16).	B.C. 599
B.C. 586.	Destruction of Jerusalem by the Chaldeans in the 19th year of Nebuchadnezzar (II Kings, XXV, 8). Second deportation of captives to Babylonia. (II Kings, XXV, 4 – 21).	B.C. 588
B.C. 561.	Jehoichin released from prison by Evil-Merodach in the 37th year of his captivity. (Jer. LII, 31.)	B.C. 562

[1] Ency. Brit., vol. XXVII, p. 77.

Monumental Date.		Usher's Date.
B.C. 538.	Edict of Cyrus permitting the Jews to return to Palestine. Many return under the leadership of Zerubabel. (Ezra I, II).	B.C. 536
B.C. 525.	Conquest of Egypt by Cambyses.	

The writer of the article on Biblical Chronology in the Encyc. Brit. considers that Usher's dates before 723 B.C. are too high, and should be considerably reduced, but, seeing that the dates of the Biblical droughts *all* agree in the most wonderful manner with the Nile's curve, it would appear to be very much open to question as to whether any correction at all should be made. It is now quite evident from the fact of the extreme accuracy with which he determined the dates after 723 B.C. that Mr. Russell's critics, and Professor Gurney in particular (who remarked in 1896 that "the marginal dates in the Bible are foreign to the text, and have no 'scientific value,' and, in fact, were merely guesses,") were speaking without a proper knowledge of the subject. The latter gentleman even went so far as to ridicule Mr. Russell's statement that there was evidence of a B.C. drought having lasted sixty years. He said—

"It is impossible to deal seriously with the evidence which Mr. Russell draws from Biblical meteorology. It seems to me that a continuous sixty years drought would completely efface three cycles, and part of a fourth."

In view, however, of the evidence which I have brought before you in this paper, you will, perhaps, now be able to judge whether any reliance can be placed on Usher's dates, and also whether the Nile's curve has demonstrated, that it is possible for extremely long droughts to have occurred in Egypt, extending even to the limit, which the Professor referred to with so much incredulity.

THE DETERMINATION OF ALKALI IN ARSENICAL DIP-FLUID.

By L. COHEN, Chemical Laboratory, Department of Agriculture.

[Communicated by F. B. GUTHRIE, F.I.C., F.C.S.]

[Read before the Royal Society of N. S. Wales, June 1, 1910.]

THE determination of alkali in dip-fluid by direct titration against standard acid is complicated by the presence of tar and finely divided foreign matter from the hides of the cattle, which it is impossible to separate by filtration, and the black colour of which precludes the use of an indicator, except in the form of test-paper.

If litmus paper is used, the carbon dioxide, and perhaps also the arsenious acid, indicate an acid reaction before all the sodium carbonate is neutralised, it consequently gives results a good deal too low. Besides this, the process of taking out a drop of the solution on a glass rod from time to time during titration, placing it on the paper, allowing it to remain a few seconds and then washing off, is a tedious one, and leaves much to be desired even if the sample is first rendered acid, boiled to expel CO_2, and then titrated back.

The composition of the cattle-dip made according to the Departmental formula is:—

Arsenic (As_2O_3) 8 lbs.	2 grams.
Washing soda 10 lbs. = Na_2CO_3 3·706 lbs.	·92 grams.
Tar $\frac{1}{2}$ gall. = 5·25 lbs.	1·31 grams.
Soap 1 lb.	·25 grams.
Water 400 gallons	1000 cc.

This solution has an alkalinity according to litmus paper of ·6 gram Na_2CO_3 per litre, although ·92 gram is present; and there is probably no actual excess of alkali over arsenic, since assuming the compound $Na_2O\ As_2O_3$ to be formed, we have ·92 gram sodium carbonate combining with 1·72 gram arsenious acid, leaving an excess of ·28 gram of the latter.

The figures obtained with litmus paper, though useful for comparative purposes would appear to have no definite significance, and the following method is submitted as being both rapid and reasonably accurate.

It depends on the fact that a sufficient excess of acid flocculates both the tar and the fine silt particles which are diffused through the dip-fluid when alkaline, this flocculent matter being then removed by filtration, and the filtrate, which will be found practically colourless on dilution, titrated against decinormal sodium hydrate with an indicator unaffected by CO_2 and As_2O_3.

To 50 cc. dip-fluid in a small beaker, run in 5 cc. normal sulphuric acid from a burette, stir, filter at once through dry paper, take 10 cc. filtrate with a pipette, transfer to a beaker and dilute with about 100 cc. water; the solution is now colourless. Add two drops methyl orange solution (cochineal is entirely unsuitable, being rapidly bleached by the arsenic) and titrate to neutrality with decinormal NaOH. The end reaction will be found perfectly sharp.

Calling n the number of cc. decinormal NaOH used, and p the number of grams Na_2CO_3 per 100 cc. of dip-fluid, then

$$p = \cdot 053 \times (10 - \frac{11}{10} n)$$

Six samples of dip-fluid were prepared containing varying quantities of arsenic and soda, and gave the following results by this method:—

Amount of Na_2CO_3 added in grams per 100 cc.		Grams As_2O_3 added.		Grams Na_2CO_3 found.		After deducting ·004 for soap.
·092	...	2	...	·095	...	·091
·092	...	1	...	·095	...	·091
·150	...	2	...	·152	...	·148
·150	...	1	...	·152	...	·148
·050	...	2	...	·054	...	·050
·050	...	1	...	·054	...	·050

(The alkalinity of the ·025 gram soap was first determined namely:—·004 gram expressed as sodium carbonate.)

It will be seen that the amounts of soda found agree closely with the amounts added, so that the method is sufficiently accurate for practical purposes.

NOTE ON MR. LAWRENCE HARGRAVE'S PAPER ON LOPE DE VEGA.

By Prof. A. C. HADDON, D.Sc., F.R.S.

(Communicated by Mr. CHARLES HEDLEY, F.L.S.)

[*Read before the Royal Society of N. S. Wales, June 3, 1910.*]

As Mr. Hargrave in his paper on Lope de Vega,[1] asks for "incidents and relics . . . it does not matter in the least if they are in the *highest degree contradictory*," (p. 52) I venture to offer the following notes:

P. 41, "at Port Macquarie . . . The blaring of the trumpets. The throbbing of the alligator drums," presumably Spanish trumpets and Australian drums? P. 42, the native church on Mabuiag, one of the western islands, was

[1] This Journal, Vol. XLIII, p. 37.

built largely from the proceeds of copper ingots, which the natives dived for on a neighbouring reef; these they sold to traders for about £500. This is what the Rev. Dr. Lawes referred to, but the statement that "This find was probably a pile of tempered copper Peruvian mining tools. All gone to the melting pot! Alack! alas!" is entirely without foundation, and further it should be noted that the copper ingots were found at least 120 miles west of the shipwreck.

P. 43, It is absurd even to suggest that coco-nuts and bows and arrows were introduced into Torres Straits by the Spaniards. The Murray Islanders invariably had only conical huts, the "gable built houses" were due to the influence of 'South Sea men' in quite recent years. The Murray Islanders are by no means "obviously blended with something that is neither Papuan nor Australian," and one would have to look for a long time to discover "Peruvian words and customs" in these islands.

P. 44, When one asks a Torres Straits native for the name of a turtle-shell mask, he never says "*Devega-Devega*," or anything like it.

P. 45, The large fish-traps or weirs, *sai*, of Murray Island and Darnley occur also in some western islands, where they are called *graz*; they are of indigenous construction and are not "turtle ponds." The only observation of value in this remarkable paper is the imperfect record on p. 46 of a ceremonial object on Stephen's Island (Uga), which evidently was connected with an initiation ceremony into a fraternity, probably analogous to the Bomai-Malu cult of the Miriam, or that of the heroes in other islands. There is no reason to doubt that Mate was the name of the custodian, the statement that "It is obvious enough to me now that Ma-te was not the man's name, but Muerte (Spanish for death)" is not worth discussion.

P. 47, The reputed destruction of this sacred object most certainly cannot be described as a "trifling thing," and to my knowledge the memory of more trifling events is retained for over twenty years.

P. 49, Daudai or Dudi is the name given to the country immediately west of the mouth of the Fly River, thus the statement "Now we know there is no place called Dow-dai to the N.W." of Darnley Island is incorrect. It was to be expected that Mr. Collingridge has not found the name De How-di or De Owdi among the shipmates of de Vega. I believe I am right in stating that there is no such term as "Oo-ber-re tobacco" in this district; tobacco is called *sokob* in the eastern islands, *sukuba* in the western and in Daudai, and the Motu of Port Moresby call it *kuku*. I am at a loss to understand what Mr. Hargrave means by Ooo-ber-re tobacco, I do not know of any place of that name which "bears N.W. from Port Moresby," nor of a place called Oo-ber-re that "bears north from Mar-wot-ter" Mawatta).

P. 50, Suspension bridges are known in various places in British Papua, for example on the Vanapa River in the Central District. "No Torres Straits natives boil and bend tortoise-shell to the shapes they want"; as a matter of fact they are clever manipulators of turtle-shell, as anyone is perfectly aware who is acquainted with the numerous turtle-shell masks in various museums. The interpretation of the turtle-shell image figured by Jukes[1] is very far-fetched. The image is well within the capabilities of the Torres Straits islanders. The fillet of the wig (it certainly is not a "helmet") worn by the image is decorated with a pattern, which is indicated very conventionally owing to the small scale of the illustration, and I do not think the original was ornamented with scrolls, as that is an orna-

[1] Voyage of the Fly, I, p. 193.

mental device foreign to the islanders, in any case it is not "Greek key scroll work," and how it could be imagined to be "the knight's motto or name, probably D E V E G A" passes my comprehension. The "Elizabethan period ruff" is the ordinary fret-work which occurs on human-face and animal masks from Torres Straits and Daudai. "The sword belt" is the common native belt, which is frequently decorated with cowry shells. Jukes was a distinguished geologist and naturalist and would not have called the figure a boy if it had a moustache; a careful inspection of the original illustration leads one to the conclusion that a crack in the turtle-shell has led to Mr. Hargrave's supposition that a moustache was intended. As for his statement that "no Straits natives have that," I do not know what to think, as the natives have naturally a great deal of hair on the face, although it is customary now for the younger men to shave in imitation of Europeans. In 1888 and again in 1898, I saw most of the natives in Torres Straits, and I have photographic proof of the occurrence of abundant hair on the face, besides my personal knowledge. What Mr. Hargrave regards as the end of a piece of bamboo between the legs of the image is probably a conventional representation of the groin-shield which was worn by warriors when fighting and often when dancing. The implied suggestion that "Mammoos" is derived from "Mama," the "Peruvian for mother," is ridiculous. The origin of the word has more than once been elucidated. I hope that these remarks will assist in "straightening" out Mr. Hargrave's theorisings. I leave Australian ethnologists to deal with his interpretation of Australian rock-markings.

* * * * *

After the reading of Prof. Haddon's note, Mr. Hargrave stated:—

I sent Prof. Haddon a copy of another paper on the same subject, read December 1909.[1] The Council has not accepted

[1] This Journal, XLIII, p. 412.

the photograph of the mining relic, the other two have not been offered.

Prof. Haddon must be perfectly familiar with the alligator drums of Torres Straits, and the restricted area where they are used.

It would add greatly to the value of Prof. Haddon's note if he could examine the tortoise-shell figure. I can see no reason why it should not still be in existence.

The weirs seem suitable for retaining fish, turtle, and other denizens of the sea.

I have ceased to hope that the Hogar relic will be found.

If Prof. Haddon will follow out the cross bearings of Coo-ber-re and Oo-ber-re he will find that they meet far in the interior of New Guinea, and in the neighbourhood of the Fly River. I always carried a compass and know the bearings indicated to me at An-nua-par-ter and Mar-wot-ter are closely recorded.

I mentioned a trestle bridge at Kewi, not a suspension bridge ; it has doubtless been renewed several times since I saw it.

An examination of the tortoise-shell figure will show whether the groin shield is shell or bamboo. Members will see the groin-shield's ancestor in the reproduction of an old copper plate showing two huntsmen with falcons,[1] and doubtless in many other old pictures. The cut of the trousers is quite plain, and would be rather startling in Bond Street to-day. Mariano de Castro is shown in Sydney wearing a similar pair of trousers.

The Dow-dai sentence that displeases Prof. Haddon arises from my inability, in 1876, to ascertain the situation of Dowdai. Mama is Peruvian for mother, see Prescott.

[1] Scientific American Supplement, March 12, 1910.

It is deplorable that the fact of an ordinary engineer, chancing to see in a local paper a photograph of a so-called prehistoric fish-trap, and associating it with the previously unknown fate of one of Spain's boldest seamen, should in any sense be offensive to a scientist. An engineer knows that when he takes his sharpest pencil and runs it along the edge of his best tee-square, the resulting line does not lie evenly between its extremities. A huntsman knows his dog only follows the scent by continually getting off it; and I have a suspicion that a scientist only advances knowledge by seeing things that his predecessors failed to see, or viewed through a fog.

ON AUSTRALIAN AVIAN ENTOZOA.

By T. HARVEY JOHNSTON, M.A., B.Sc., Assistant Government Microbiologist.

(From the Government Bureau of Microbiology, Sydney, New South Wales).

[*Read before the Royal Society of N. S. Wales, June 1, 1910.*]

IN this note there is an endeavour to bring together under each host a list of endoparasites recorded as occurring in birds in Australia as well as the references to their occurrence. These have been allotted under their respective headings as Protozoa, Trematoda, Cestoda, Nematoda, and Acanthocephala. Many of our birds have a geographical range extending far beyond Australia, some of them being common Old-world forms. Many parasites have been described from some of these hosts, but unless the entozoa were taken from birds from the Australian region, they

have been neglected in this account. The term Australia is being used in a wide sense so as to include forms from New Guinea and the adjacent islands such as Bismarck Archipelago and the Aru Islands.

Following the scientific name of each bird, there will be found its number (indicated as M.) in Gregory Matthews'[1] Hand-list. As this ornithologist follows R. Bowdler Sharpe's Hand-list of Birds[2] in regard to genera and species, his list may be considered as authoritative in regard to the correct nomenclature of the birds in question. Then follows its number (H.) in the second edition of Robert Hall's Key.[3] Thus the host in question may be readily placed. The popular name given is in most cases taken from Hall's List. The range of each bird may be found by consulting either of these works, more especially the former.

My thanks are due to my colleague at the Bureau, Dr. J. Burton Cleland, who has very materially assisted me with specimens of birds and helminths; to Mr. A. J. North, Ornithologist to the Australian Museum, Sydney, who has kindly identified many birds for me and has helped me in regard to certain points in avian synonymy; to Dr. F. Tidswell, the Director of the Bureau; to Mr. G. P. Darnell-Smith, also of this Bureau; and Mr. A. S. Le Souef, Curator of the Royal Zoological Gardens, Sydney, and Mr. T. Steel, for kindly sending me specimens.

It may not be out of place to mention that this paper is part of a scheme to more fully investigate our bird-life.

[1] G. Matthews, "Hand-list of the Birds of Australasia," published as a Supplement to the *Emu*, vol. VII, 1907-8, 108 pages.

[2] R. Bowdler Sharpe, "A Hand-list of the Genera and Species of Birds," (British Museum Publications, the volumes extending over many years.) I have consulted this work for information concerning nomenclature.

[3] R. Hall, "A key to the Birds of Australia," Melbourne, 2nd Edition, 1906.

Dr. Cleland[1] has undertaken to examine the stomach contents with a view to finding out the economic value of these birds (from an agricultural standpoint) and has just published some interesting information along these lines. We are endeavouring conjointly to study our avian haematozoa, while I am more particularly interesting myself in the helminths, especially the cestodes.

In addition to the parasites enumerated, there is now at my disposal a goodly number of tapeworms from various Australian birds, but as these are not yet worked up no reference is being made to them in this paper. Many of the following references† are also to be found in Linstow,[2] Fuhrmann,[3] and Sweet.[4]

Order CASUARIIFORMES.

(A) Family DROMÆIDÆ.

1. *Dromaeus novae-hollandiae*, Lath. (M. 1, H. 764). Emu.

Cestoda:—i. *Davainea australis*, Krabbe, *Dansk. Vidensk. Selsk. skr. naturvid. math.* Afd., (5) Vol. VIII, 1869, p. 343 (Australia); Krefft, *Trans. Entmol. Soc., N.S. Wales*, II, 1871, p. 210; Johnston, *Journ. Roy. Soc. N.S. Wales*, XLIII, 1909, p. xxix (New South Wales).

This species was very briefly described by Krabbe as *Taenia australis*, his specimen coming from an Emu which had died in the Copenhagen Zoological Gardens after having been there a considerable time. This led Krabbe to remark that the cestode might be proper to this bird, or that this

[1] Cleland, "Examination of Contents of Stomachs and Crops of Australian Birds, *Agric. Gazette*, N. S. Wales, XXI, 1910, pp. 401-5; and in the *Emu*, IX, April, 1910.

[2] Linstow, O. v., "Compendium der Helminthologie," 1878; Nachtrag 1889.

[3] Fuhrmann, O., *Zoolog. Jahrb.*, Suppl. Bd. x, Heft 1, 1908.

[4] Sweet, G., *Proc. Roy. Soc., Victoria*, XXI, (N.S.) 1908, pp. 454-502.

All works which I have not been able to consult, but which are mentioned in this paper will be designated thus †.

might have been a case of "accidental" infection during its stay in the Gardens.

Blanchard[1] recognised from Krabbe's figures that this parasite belonged to the genus *Davainea*. Krefft merely mentioned the worm. I formally recorded its occurrence in this host in New South Wales, and have recently examined specimens of *D. australis* collected from the intestine of an Emu in the Strelley River district (North-west of West Australia) by Dr. J. B. Cleland.

ii. *Cotugnia collini*, Fuhrmann, *Cent. f. Bakt.*, I, Orig., XLIX, 1909, p. 116.

This parasite was collected in Eastern Australia.

(B) Family CASUARIIDÆ.

2. *Casuarius casuarius*, Linn. (Syn. *C. galeatus*, Bonn.) Cassowary.

This species does not live on the mainland, but is restricted to New Guinea and the adjacent islands. The Australian representative is *C. australis*, Wall.

Nematoda:—*Sclerostomum* (= *Strongylus*) *boularti*, Mégnin,† *Journ. d. l'Anat. et Physiol.*, Paris, XX, 1884, p. 455—found in the trachea, (locality ?)

Order COLUMBIFORMES.

(A) Family COLUMBIDÆ.

3. *Macropygia nigrirostris*, Salvad.

Nematoda:—*Heterakis australis*, Von Linstow, *Arch. f. Naturg.*, LXIII, 1897, p. 285. (Bismarck Archipelago).

(B) Family TRERONIDÆ.

4. *Carpophaga vanwycki*, Cass. A fruit-eating Pigeon.

Cestoda:—*Cittotaenia Kuvaria*, Shipley, "Entozoa" in Willey's "Zoological Results," V, 1900, p. 552. (New Britain.)

[1] Blanchard, *Mem. Soc. Zool., France*, IV, 1891, p. 434.

Shipley described this worm as *Coelodela Kuvaria*, making it the type of a new genus *Coelodela*. Fuhrmann[1] showed that this was a synonym of *Cittotaenia*.

5. *Zonoenas brenchleyi*, Gray (Syn. *Carpophaga brenchleyi*, Gray). Brenchley's Fruit-pigeon.

Nematoda:—*Ceratospira ophthalmica*, Von Linstow, *Arch. f. Naturg.*, XLIII, 1897, p. 286. (Bismarck Archipelago.)

This Filariid was taken from the orbital cavity of the above pigeon and originally described as *Ancyracanthus ophthalmicus*. Ransom[2] removed it into the genus *Ceratospira*.

(C) Family GOURIDÆ.

6. *Goura albertisi*, Salvad.

Cestoda:—*Davainea goura*, Fuhrmann, *Centr. f. Bakt.*, I, Orig., XLIX, 1909, p. 106, (New Guinea.)

7. *Goura coronata*, Linn. The crowned pigeon.

Cestoda:—*Echinococcus sp.*, Crisp, *Proc. Zool. Soc., Lond.*, 1860, p. 192.

Crisp recorded the occurrence of "hydatids (*Echinococci*) in the liver and other viscera" of one of these birds which had died at the London Zoological Gardens. Linstow[3] quotes Crisp's reference, but sets down the parasite as *Echinococcus gourae coronatae*, by which he means merely *Echinococcus* from *Goura coronata*.

(D) Family PERISTERIDÆ.

8. *Caloenas nicobarica*, Linn. The Nicobar pigeon.

Cestoda:—*Davainea paucitesticulata*, Fuhrmann, *Centrb. f. Bakt.*, I, Orig., XLIX, 1909, p. 106.

The locality from which the parasite was collected is not stated, though the geographical distribution of the host is

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[1] Fuhrmann, *Centr. f. Bakt.*, I, Orig. XXIX, 1901, p. 761; *Ibid.*, XXXII, 1902, p. 142, and *Zool. Jahrb. Syst.*, XXII, 1905, p. 312.

[2] Ransom, "Dept. Agric. U.S.A., Bur. Animal Ind." Bull. 60, 1904, p. 30,

[3] V. Linstow, "Compendium der Helminthologie," 1878, p. 120.

given. As a number of other parasites collected from various birds in New Guinea are described in the same paper, it may be assumed that Papua was the locality from which this cestode was obtained.

No parasites have, as far as I know, been described from pigeons (native) from the mainland of Australia.

Order RALLIFORMES.

Family RALLIDÆ.

9. *Porphyrio melanonotus*, Temm., (M. 62, H. 591). The Bald Coot.

   Trematoda:—*Distomum sp.*, Krefft, *Trans. Entomol. Soc. N.S. Wales*, II, 1871, p. 213. (N.S. Wales or Queensland.)

Order PODICIPEDIDIFORMES.

(A) Family PODICIPEDIDÆ.

10. *Podicipes novaehollandiae*, Steph. (M. 65, H. 739). The Black-throated Grebe.

    Cestoda,—i. *Taenia novaehollandiae*, Krefft, *l.c.*, p. 216. (New South Wales or Queensland.)

    ii. *Taenia paradoxa*, Krefft, *l.c.*, p. 217. (New South Wales or Queensland.)

These two parasites were very imperfectly described and roughly figured by Krefft. Neither belongs to the genus *Taenia*, but until the types have been re-examined, their systematic position is not known. Krefft described the forms as infesting the intestine of the little grebe *Podiceps australis*. The generic name is evidently meant for *Podicipes*. I cannot find any reference to the specific name. This difficulty seems to have occurred to Professor Fuhrmann,[1] who lists the tapeworms under *Lophaethia cristata*, Linn., (M. 67, H. 741) the tippet-grebe. Mr. A. J. North kindly informed me that Krefft's *P. australis* is really *P.*

[1] Fuhrmann, "Die Cestoden der Vögel," *Zoolog. Jahrb.*, Suppl. Bd. x, Heft 1, 1908, p. 133.

novaehollandiae, hence it is under this host that the parasites should in future be placed. Fuhrmann[1] has suggested that *Taenia novaehollandiae* may be *Dioicocestus*. I prefer to leave it as *T. novaehollandiae* until Krefft's types shall have been re-examined.

The name *Taenia paradoxa* is preoccupied having been used by Rudolphi in 1809 for a cestode infesting species of *Scolopax*, *Charadrius*, and *Gallinago*. Rudolphi's parasite (= *Choanotaenia paradoxa*, Rud.) is quite distinct from Krefft's species, which, like his *T. novaehollandiae*, possesses doubled genitalia in each segment, a fact not mentioned by Krefft in regard to his *T. paradoxa*. The types are so badly preserved that it is difficult to say whether *T. paradoxa* and *T. novaehollandiae* are distinct, and accordingly I have refrained from re-naming *T. paradoxa*, Krefft, until I have made out the anatomy of both species.

Many parasites have been described from *L. cristata* from other parts of the world, but not from Australia.

Krefft does not give a definite locality for most of his specimens.

Order SPHENISCIFORMES.

Family SPHENISCIDÆ.

11. *Aptenodytes sp.* A penguin.

Cestoda:—*Taenia zederi*, Baird, *Proc. Zool. Soc. Lond.*, 1853, p. 24 (Antarctic); Baird, *Ann. Mag. Nat. Hist.*, (Ser. 2), 1855, p. 75; Baird, "Catalogue of Entozoa in British Museum," 1853, p. 85.

This parasite was obtained from the stomach of an Antarctic penguin. Baird does not mention any scientific name for the host. Krefft[2] merely quoted Baird's reference. Diesing[3] placed the parasite under *Aptenodytes sp.* Lin-

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[1] *Loc. cit.*, p. 88.

[2] Krefft, *Trans. Entomol. Soc. N. S. Wales*, ii, 1871, p. 211.

[3] Diesing, *Sitzb. d. K. Akad. Wien.*, XLIX, 1864, p. 417. †

stow[1] and Fuhrmann[2] have followed Diesing. Krefft and Sweet[3] have given the host as a penguin, following Baird. Krefft called the worm *T. cederi.* The common penguin in Antarctica appears to be the Emperor penguin, *Aptenodytes fosteri*, Gray (M. 68, H. —), this being as far as I know the only species of that genus found in those regions. Probably the assumption that Baird's specimen came from an *Aptenodytes* is correct. Fuhrmann[4] in 1899 suggested that *T. zederi* might be a synonym of *Tetrabothrius macrocephala*, Rud., but in 1908 he[5] regarded it as an undefined species.

Order PROCELLARIIFORMES.

(A) Family PUFFINIDÆ.

12. *Priocella glacialoides*, Smith (Syn. *Thalassoeca glacialoides*, Smith), (M. 87, H. 677). The silver-grey petrel.

Cestoda:—*Tetrabothrius heteroclitus*, Dies. Linstow, "Report on the Entozoa," in Challenger Report, Zoology, XXIII, 1888, p. 14. (Southern Ocean—Antarctic.)

This species was taken by the Challenger Expedition, from *Priocella glacialoides* and from the Cape Petrel, *Daption capensis*, Linn. (M. 101, H, 688), the latter bird being captured in the South Atlantic and consequently, is not included here. The parasite was described by Linstow as *Tetrabothrium auriculatum*, Linst., but Fuhrmann[6] has shown that both this species and *Taenia sulciceps*, Baird, are synonyms of *Tetrabothrius heteroclitus*, Dies.

(B) Family DIOMEDEIDÆ.

13. *Diomedea albatrus*, Pall. (Syn. *D. brachyura*, Temm.) (M. 108, H. 696). The short-tailed Albatross.

[1] Linstow, "Compendium der Helminthologie," 1878, p. 175.
[2] Fuhrmann, *Zool. Jahrb.* Suppl., 1908, *l.c.*, p. 136.
[3] Sweet, *Proc. Roy. Soc. Victoria*, (n.s.) XXI. 1908, p. 478.
[4] Fuhrmann, *Centr. f. Bakt.*, I, Orig., XXV, 1899, p. 873.
[5] Fuhrmann, *Zool. Jahrb.*, Suppl. X, 1908, p. 93.
[6] Fuhrmann, *Centr. f. Bakt.*, I, Orig., XXV, 1899, p. 874.

Cestoda:—i. *Tetrabothrius torulosus*, Linstow, "Report on the Entozoa," Challenger Report, Zoology, 1888, p. 14.

This was described very briefly by Linstow from specimens collected in the Pacific Ocean, probably to the north of Australia. The inclusion of this and the following parasites from this host in our known Australian entozoan fauna is thus doubtful. Fuhrmann[1] gave much fuller account of the worm in 1899.

ii. *Tetrabothrius heteroclitus*, Dies., Linstow, *l.c.*, 1888, p. 13.

Linstow examined some headless fragments also obtained by the Challenger and described them as belonging to a new species *Taenia diomedeae*, Linst., though he stated that this might be identical with *Taenia sulciceps*, Baird,[2] a parasite collected from *Diomedea exulans*, Linn. Fuhrmann[3] showed that *T. diomedae*, Linst., *T. sulciceps*, Baird, and *Tetrabothrium auriculatum*, Linst., were all synonymous with *Prosthecocotyle* (i.e. *Tetrabothrius*) *heteroclita*, Dies.

Nematoda:—*Ascaris diomedeae*, Linstow, *l.c.*, 1888, p. 6.

This round worm was taken from the stomach.

14. *Diomedea exulans*, Linn. (M. 109, H. 695). The great wandering albatross.

Cestoda:—*Tetrabothrius diomedeae*, Fuhrmann in Shipley, (*vide infra*) p. 557. Shipley, "Entozoa" in Willey's Zoological Results, v, 1900. p. 557, (Western Pacific to N.E. of Australia ?)

These specimens were collected by Dr. Willey during his expedition to the islands lying to the north-east of Australia. The species in question was described by Fuhrmann as *Prosthecoctyle diomedeae*, and published along with

[1] Fuhrmann, *Centr. f. Bakt.*, Orig., xxv, 1899, p. 871; *Proc. Roy. Soc. Edinb.*, xxii, 1899, p. 643.

[2] Baird, *Proc. Zool. Soc. Lond.*, 1859, p. 111; *Ann. Mag. Nat. Hist.*, (3) iv. 1859, p. 240.

[3] Fuhrmann, *Centr. f. Bakt.* Orig., xxv, 1899, p. 874; *Proc. Roy. Soc. Edinb.*, xxii, 1899, p. 648.

some further notes by Shipley, in the latter's account of the entozoa collected by Willey. *Prosthecocotyle* is now generally regarded as a synonym of *Tetrabothrius*.

Nematoda:—*Gnathostoma shipleyi*, Stossich, *Boll. Soc. Adriat.*, xx, 1900, and in Shipley *(vide infra)* p. 561. Shipley, *l.c.*, p. 560. (Western Pacific, etc.)

This interesting worm was also collected by Willey.

Order LARIFORMES.

Family Laridæ.

15. *Sterna bergii*, Licht. (M. 125, H. 647). The crested tern.

Trematoda:—*Holostomum musculosum*, Johnston, (S. J.), *Proc. Linn. Soc. N. S. Wales*, xxix, 1904, p. 112. (New South Wales.)

Though several parasites have been described from this host, the above mentioned is the only reference known to me, dealing with the identification of forms collected in Australia.

16. *Larus novae-hollandiae*, Steph. (M. 137, H. 659). The silver gull.

Trematoda:—*Holostomum Hillii*, Johnston, (S. J.), *l.c.*, 1904, p. 111. (New South Wales.)

Order CHARADRIFORMES.

Family Charadriidæ.

17. *Haematopus fuliginosus*, Gld., (Syn. *H. unicolor*, Wagl) (M. 145, H. 602). The sooty oyster catcher.

Linstow[1] described a tapeworm *Taenia increscens*, Linst. obtained from this bird in New Zealand by the Challenger Expedition. It is still imperfectly known and I am not including it in this list of Australian entozoa.

18. *Charadrius dominicus*, Müll. (M. 151, H. 608). The lesser golden plover.

[1] Linstow, *l.c.*, 1888, p. 13.

I have taken from the intestine of this bird some small cylindrical distomid trematodes (*Echinostomum sp.*) whose anterior end is provided with a circlet of hooks. (Near Sydney, N. S. Wales.)

19. *Himantopus leucocephalus*, Gould, (M. 161, H. 618). The white headed stilt.

Trematoda:—*Monostomum sp.*

Dr. Cleland collected a number of flukes belonging to the Monostomidæ and apparently to this genus. They were found in the oesophagus and in the body cavity of the bird. I cannot state which was the correct habitat, as there was a perforation of the wall of the alimentary canal. (Murray River, South Australia).

Cestoda:—i. *Taenia coronata*, Krefft, *l c.*, p. 220. (N S.W.)

ii. *Taenia rugosa*, Krefft, *l.c.*, p. 223. (N.S.W.)

Both of these species are insufficiently described, and have not as a consequence, been assigned to their true genera. Fuhrmann[1] lists them under the imperfectly known forms.

In regard to *T. rugosa*, Krefft, the specific name *rugosa* was already preoccupied in the genus *Taenia* being used by Diesing[2] for a tapeworm from the small intestine of a Brazilian monkey, *Cebus (Eriodes) hypoxanthus*. Consequently Krefft's species requires re-naming. I would suggest that this worm be dedicated to my friend, Mr. Charles Hedley, Assistant Curator of the Australian Museum, Sydney. As I hope to point out in a later communication, this parasite in not a *Taenia*, but belongs to the family *Acoleidae*, and probably to the genus *Acoleus*. Accordingly the helminth may be listed temporarily as *Acoleus hedleyi*, nom. nov. Dr. Cleland has recently

[1] Fuhrmann, *Zool. Jahrb.*, Suppl. *l.c.*, 1908, p. 93.

[2] Diesing, " Systema helminthum, I, 1850, p. 502.

collected the same species from the intestine of the above named stilt, at Tailem Bend, Murray River, South Australia.

The name *Taenia coronata* was already used by Creplin for a cestode which also infests Charadriid birds (*Œdicnemus crepitans*, Temm. and *Ægialites nivosa*, Cass). A comparison between Krefft's species and the description of *T. coronata*, Crepl. (= *Choanotaenia coronata*, Crepl.) as given by Diesing[1] and Krabbe, shows them to be distinct. As a specific name, *australiensis* might be given. A brief examination of Krefft's type leads me to regard it as a *Dilepis*. Both *Acoleus hedleyi* and *Dilepis australiensis* will form subjects for further study, as the Curator of the Australian Museum has kindly given me access to the type material.

iii. *Davainea sp.*

I have identified as belonging to this genus some very small tapeworms of about two mm. in length, and consisting of about a dozen segments, collected by Dr. Cleland from a bird shot at Tailem Bend, Murray River, South Australia.

iv. *Hymenolepis sp.*

A rather small unarmed species of this genus was also collected by Dr. Cleland from the intestine of the same bird. (Murray River, South Australia.)

Order ARDEIFORMES.

(A) Family Ciconiidæ (Ciconiinæ in "Matthews' Handlist")

20. *Xenorhynchus asiaticus*, Lath., (M. 199, H. 723). The jabiru or black-necked stork.

Cestoda:—*Clelandia parva*, Johnston, (T. H.), *Jour. Proc. Roy. Soc. N. S. Wales*, XLIII, 1909, p. 139. (N. S. Wales.)

There is a slight doubt as to the true host of this parasite.

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[1] Diesing, *l.c.*, p. 537. [2] Krabbe, *l.c.*, p. 275.

(B) Family ARDEIDÆ.

21. *Herodias timoriensis*, Less. (syn. *H. alba*, Gld. nec Linn.) (M. 203, H. 710). The white egret.

Trematoda:—*Distomum sp.*, Krefft, *l.c.*, p. 213. (New South Wales or Queensland.)

22. *Notophox novae-hollandiae*, Lath., (syn. *Ardea novae-hollandiae*, Lath.) (M. 204, H. 711.) The white-fronted heron.

Trematoda:—*Holostomum simplex*, Johnston, (S. J.), *Proc. Linn. Soc. N. S. Wales*, XXIX, 1904, p. 112. (N.S.W.)

23. *Notophoyx pacifica*, Lath. (syn. *Ardea pacifica*, Lath.) (M. 215, H. 712). The white-necked heron or pacific crane.

Trematoda:—*Distomum sp.*, Krefft, *l.c.*, p. 213. (N.S.W. or Queensland).

24. *Nycticorax caledonicus*, Gmelin (M. 210, H. 717). The night heron or Nankin crane.

Nematoda:—*Ascaris sp.* (an immature female) Linstow, *Arch. f Naturg.*, LXIII, 1897, p. 283. (Bismarck Archipelago.)

Nicholls[1] mentioned finding tapeworms in this host in Victoria, but the reference has no scientific value.

Many entozoa are known from some members of this family which are found in Australia, e.g. *Ardea cinerea*, Linn., *Herodias timoriensis*, Less., etc., but since they have not been recognised in Australia, they are not included in this list.

Order ANSERIFORMES.

Family ANATIDÆ.

25. *Chenopsis (Chenopis) atrata*, Lath. (syn. *Cygnus atratus* Lath.) (M. 216, H. 744). The black swan.

Trematoda:—i. *Hemistomum intermedium*, Johnston, (S. J.), *Proc. Linn. Soc. N. S. Wales*, XXIX, 1904, p. 110. (N.S.W.)

[1] Nicholls, *Victorian Naturalist*, XXI, 1904-5, p. 147.

ii. *Monostomum sp.*

I have some large flukes (family *Monostomidæ*) belonging to this genus, taken from the pharynx of a black swan in Victoria, by Mr. A. S. Le Souef.

Krabbe[1] in 1869 described a cestode *Taenia liophallos* (=*Hymenolepis liophallos*, Krabbe) from Leuckart's collection, taken from this host. He also[2] gives a very brief account of *Taenia micrancristrota*, Wedl.[3] (=*Hymenolepis micrancristrota*, Wedl.) described from material collected in Hungary. Linstow[4] recorded both of these tapeworms under this host. Fuhrmann[5] does not place either of these under this bird, but under *Cygnus musicus*, Bechst. Ransom[6] lists the two under *Olor cygnus*, Linn. Sharpe[7] regards both *C. musicus* and *O. cygnus* as synonyms of *Cygnus cygnus*, Linn.

Besides the above cestodes, a nematode, *Heterakis vesicularis*, Rud. (=*H. papillosa*, Bloch) has been recorded by Schneider[8] as being taken from the caecum of *Chenopsis atrata* in the Zoological Gardens, Berlin. He mentioned that the bird had lived a long time in the Gardens and consequently the occurrence of this parasite in Australia did not necessarily follow. In 1906, Linstow[9] gave an account of another nematode *Heterakis circumvallata*, Linst., from this bird (Königsberg Museum) but no locality is given.

Both Sharpe[7] and Matthews[10] give the range of this bird as "Australia generally and Tasmania." It has been

1 Krabbe, *Bidrag til Kundskab om Fuglenes Bændelorme*, 1869, p. 43.
2 Krabbe, *l.c.*, p. 43.
3 Wedl., *Sitsb. d. K. Akad.*, Wien., VIII, p. 6.†
4 Linstow, "Compendium der Helminthologie," 1878, p. 150.
5 Fuhrmann, *Zool. Jahrb.*, Suppl. Bd., x, Heft 1, 1908, p. 149.
6 Ransom, "Smithsonian Instit. U.S. Nat. Museum, Bull. 69," 1909, pp. 94, 111.
7 Sharpe, "Handlist of Birds," Vol. I, 1899, pp. 207, 208.
8 Schneider, "Monographie der Nematoden," 1866, p. 76.
9 Linstow, *Arch. f. Naturg.*, 1906, I, (3) p. 251.
10 Matthews, "Handlist of the Birds of Australasia," 1908, p. 34.

introduced into Europe, and has apparently become parasitised by helminths which occur normally in other birds. I am omitting the cestodes and nematodes from this list of Australian avian entozoa.

26. *Anas superciliosa*, Gmel., (M. 226, H. 753). The black duck.

Cestoda:—i. *Taenia cylindrica*, Krefft, *l.c.*, p. 220, (N.S.W. or Queensland.)

ii. *Taenia flavescens*, Krefft, *l.c*, p. 219. (N. S W. or Queensland.)

iii. *Taeuia bairdii*, Krefft, *l.c.*, p. 224. (N.S.W. or Queensland.)

iv. *Fimbriaria pediformis*, Krefft, *l.c.*, p. 222. (N.S.W. or Queensland.)

Unfortunately none of Krefft's species are recognisable from his figures and descriptions, and but for the fact that his types (or at any rate most of them) have been preserved, one would be justified in disregarding them. The three first mentioned cestodes are very imperfectly described. Their true generic position is unknown. The fourth species which was described as *Taenia pediformis*, also infests the teal (*Nettium castaneum*, Eyton). Fuhrmann[1] suggests that this species is probably a synonym of *Fimbriaria fasciolaris*, Pall. A cursory examination of the single specimen of *T. pediformis* now in the Australian Museum, Sydney, leads me to think that Fuhrmann is right. A thorough examination of Krefft's type would decide the question of identity. Miss Sweet[2] wrongly quotes Krefft in reference to the occurrence of *Taenia malleus*, G., (i.e. *Fimbriaria fasciolaris*, Pall.) in Australia.

27. *Nettium (Nettion) castaneum*, Eyton, (syn. *Anas castaneum*, Eyton). (M. 227, H. 754). Teal.

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[1] Fuhrmann, *Zool. Jahrb.*, Suppl. Bd. x., Heft 1, 1908, p. 91.

[2] Sweet, *Proc. Roy. Soc., Victoria*, (n.s.) xxi, 1908, p. 476.

Protozoa:—*Halteridium nettii*, Johnston, T. H. and Cleland, in *Proc. Linn. Soc. N.S.W.*, 1909, p. 503. (N.S.W.)

This sporozoan infests the red-blood corpuscles. It was first published under the name *H. nettionis*, a "lapsus calami" for the genitive *H. nettii.*

Cestoda:—*Fimbriaria pediformis*, Krefft, *l.c.*, p. 222. (N. S. Wales or Queensland.)

Krefft gives *Anas punctata* as the host of this worm. Mr. North informed me that the name of this species is *N. castaneum*, Eyton. Linstow does not mention this host in the Supplement to his Compendium.

28. *Spatula rhynchotis*, Lath. (M. 231, H. 757). The blue-winged shoveller.

Cestoda:—*Taenia flavescens*, Krefft, *l.c.*, p. 219. (N.S.W. or Queensland.)

This tapeworm also occurs in *Anas superciliosa.*

29. *Aythya australis*, Gould (syn. *Nyroca australis*, Gld.) (M. 234, H. 761). The white-eyed duck or widgeon.

Cestoda:—*Diploposthe tuberculata*, Krefft, *l. c.*, p. 215. (N.S.W. or Queensland.)

This tapeworm was indifferently described by Krefft as *Taenia tuberculata.* Monticelli[1] regarded it as a synonym of *Taenia bifaria* v. Sieb. In 1891 Blanchard[2] suggested that it might belong to the genus *Ophryocotyle.* Diamare[3] in 1900 referred to the imperfect account given by Krefft. Fuhrmann[4] in 1906 showed that *T. bifaria* was identical with *Diploposthe laevis*, Bloch, and stated that *T. tuberculata* was almost certainly a *Diploposthe* and perhaps synonymous with *D. laevis*, though the wide difference in the geographical distribution of the hosts in each case led

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[1] Monticelli, *Boll. della Soc. d. nat. in Napoli*, v, 1891, p. 151.
[2] Blanchard, *Mem. Soc. Zool. France*, IV, 1891, p. 443.
[3] Diamare, *Centr. f. Bakt.* etc., XXVIII, 1900, p. 849.
[4] Fuhrmann, *Centr. f. Bakt.*, I, Orig., XL, pp. 217 – 224.

him to regard it as being probably a different species. My examination of Krefft's material shows that the parasite is a typical *Diploposthe*, but I am not yet certain of its identity or otherwise, with *D. laevis*. Fuhrmann[1] in 1908 listed it as a different species, viz., *D.* (?) *tubercolata*, the specific name being evidently a misprint for *tuberculata*.

30. *Biziura lobata*, Shaw (M. 236, H. 763). The musk duck.

Cestoda:—*Taenia moschata*, Krefft, *l.c.*, p. 223. (N S.W. or Queensland.)

An imperfectly known form.

Order PELICANIFOMES.

Family PLOTIDÆ.

31. *Plotus novae-hollandiae*, Gould (M. 242, H. 729.) The darter.

Nematoda:—*Ascaris sp*, Krefft, *l.c.*, p. 213. (N.S.W. or Queensland.)

No parasites appear to have been identified from Australian material collected from members of other families (e.g. *Phalacrocoracidae*, *Pelicanidae*, etc.) belonging to this order of birds.

Order ACCIPITRIFORMES.

Family FALCONIDÆ.

32. *Circus spilothorax*, Salvad. and D'Alb. A harrier.

Nematoda:—*Heterakis dolichocerca*, †Stossich, *Boll. Mus. Genova*, 1902 No. 106. (New Guinea.)

33. *Astur fasciatus*, Vig. and Horsf. (syn. *A. approximans*, Vig. and Horsf.). (M. 258, H. 24.) The goshawk.

Acanthocephala:—*Echinorhynchus sp.*

I have taken this worm, a comparatively long and thin parasite, from the intestine. (Near Sydney, N.S.W.)

[1] Fuhrmann, *Zool. Jahrb.*, Suppl., Bd. x, 1, 1908, p. 85.

34. *Baza bismarcki*, Sharpe. A crested hawk.
Nematoda:—*Ascaris australis*, Linstow, *Arch. für Naturg.*, LXIII, 1897, p. 282. (Bismarck Archipelago.)

The parasite was taken from the stomach of this bird. The same species has been described as inhabiting the intestine of an owl, *Ninox odiosa*, Scl. (vide infra).

35. *Falco lunulatus*, Lath. (M. 277, H. 15.) The little falcon (white-fronted falcon).
Nematoda:—*Filaria sp.*

Some long nematodes collected by Dr. Cleland from the mesentery of this falcon at Burracoppin, West Australia in 1907, belong to this genus.

36. *Hieracidia berigora*, Vig. and Horsf. (M. 278, H. 16). The striped brown hawk.
Nematoda:—*Filaria guttata*, Schneider, "Monogr. d. Nematoden," 1866, p. 92. (South Australia.)

Order STRIGIFORMES.

Family BUBONIDÆ.

37. *Ninox odiosa*, Sclater.
Nematoda:—i. *Filaria sp.*, Linstow, *Arch. f. Naturg.*, LXIII, 1897, p. 284. (Bismarck Archipelago.)

The specimens were taken from the body cavity, and since they were immature, could not be specifically determined.

ii. *Ascaris australis*, Linstow, *l.c.*, p. 282. (Bismarck Archipelago.)

As mentioned above, this parasite occurs also in a hawk *Baza bismarcki*, Sharpe.

38. *Ninox boobook*, Lath. (M.283, H.29). The bookook owl
Keartland[1] mentions that he found great numbers of thread worms between the skin and the skull of this bird, but his reference is of no value for the purpose of this paper.

[1] Keartland, *Victorian Naturalist*, XXI, 1904-5, p. 147.

Order PSITTACIFORMES.

(A) Family LORIIDÆ.

39. *Lorius erythrothorax*, Salvad.

Cestoda:—*Monezia trichoglossi*, Linstow, Diamare, *Centr. f. Bakt.*, I, Orig., XXVIII, 1900, p. 846; and †*Boll. Mus. Zool. Anat. comp.*, *Genova*, No. 91, 1900. (New Guinea.)

40. *Trichoglossus novae-hollandiae*, Gmel. (syn. *T. swainsoni*, Jard. and Selby). (M. 301, H. 468). Blue-bellied lorikeet or Blue Mountain lorikeet.

Nematoda:—*Filaria sp.*, Bancroft, *Proc. Roy. Soc. Queensland* VI, 1890, p. 61. (Queensland.)

Bancroft found embryo-filariæ (Microfilaria) in the blood of this bird.

Cestoda:—*Moniezia trichoglossi*, Linstow, "Reporton Entozoa Challenger Rep.," Zool., XXIII, 1888, p. 14. (North Queensland.)

(B) PSITTACIDÆ.

41. *Eclectus pectoralis*, Müll. The purple-breasted parrot.

Nematoda:—*Hystrichis sp.?*

I have a few specimens of a nematode *(Strongylidae)* apparently belonging to this genus, taken from this host by Mr. A. S. Le Souef, the parrot coming originally from New Guinea.

(C) Family CYCLOPSITTACIDÆ.

42. *Cyclopsittacus suavissimus*, Sclater (syn. *S. nanus*, De Vis.)

Cestoda:—*Moniezia trichoglossi*, Linstow, Diamare, *Centr. f. Bakt.*, I, Orig., XXVIII, 1900, p. 846; and †*Boll. Mus. Zool. Anat. Comp. Genova*, No. 91, 1900. (New Guinea.)

43. *Cyclopsittacus diophthalmus*, Hombr. and Jacq.

Cestoda:—*Moniezia Beauforti*, Janicki,† in "Nova Guinea Rés. Expéd. Sc. Néerlandaises," Nouvelle Guinea, V, 1906. (New Guinea.)

(D) Family Cacatuidæ.

44. *Cacatua roseicapilla*, Vieill. (M. 324, H. 489.) The Rose-breasted Cockatoo (Galah).

Cestoda :—*Davainea leptosoma*, Dies. (Australia.)

I have not been able to find the reference to the occurrence of this tapeworm in above-named cockatoo, and am giving this reference, *fide* Fuhrmann[1] (1908).

A good deal of discussion has taken place regarding the correct nomenclature of one of the above cestodes, *Moniezia trichoglossi*. It was originally described by Linstow[2] from fragmental material collected by the Challenger Expedition from *Trichoglossus novae-hollandiae*. He regarded it as a new species, and called it *Taenia trichoglossi*. In 1900, Diamare[3] described a parasite from *Cyclopsittacus suavissimus* and *Lorius erythrothorax*, which he named *Paronia carrinoi*, this being the type of a new genus *Paronia*. In 1901, he[4] mentioned that *P. carrinoi* was probably identical with *T. trichoglossi*, but thought that his name should stand as the correct one on account of the imperfect description of the latter. In 1901 Fuhrmann[5] after having examined Linstow's original material, stated that these two worms were identical, and that the genus *Paronia* was probably synonymous with *Moniezia*. He however retained the name *P. carrinoi*. In 1902,[6] he gave a much fuller account of the parasite, definitely assigning it to *Moniezia*. In a footnote to this paper, Dr. M. Braun (p. 122) mentioned that if *T. trichoglossi* were found to be identical with *P. carrinoi*, then in spite of the insufficient original description the former name must stand. In other words he

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[1] Fuhrmann. *Zool. Jahrb.*, *l.c.*, 1908, p. 160.

[2] Linstow, 1888, *l.c.*, p. 14.

[3] Diamare, *Centr. f. Bakt.* etc., XXVIII, 1900, p. 846; †*Boll. Mus. Zool. Anat. Comp. Genova*, No. 91, 1900.

[4] Diamare, *l.c.*, XXX, 1901, p. 369.

[5] Fuhrmann, *Centr. f. Bakt.* etc., XXIX, 1901, p. 758; *Zool. Anz.*, XXIV, 1901, p. 273. [6] *Id.*, *Cent. f. Bakt.*, *cit.*, XXXII, 1902, p. 122.

believed that the name should be *Paronia* (i.e. *Moniezia) trichoglossi.* Meanwhile Linstow,[1] in a short note on this subject, pointed to the fragmentary and scolex-less condition of his material and the imperfect knowledge of cestode anatomy in 1888 as reasons for his incomplete descriptions. He went on to say that he did not regard *T. trichoglossi* as a specific name but merely as a name to indicate an undefined *Taenia* from *Trichoglossus.* Fuhrmann[2] in 1908 gave a very brief summary of the above discussion, and accepted *M. carrinoi*, Diam., as the true name. I have listed the parasite under Linstow's name, as it seems to me that Braun's contention is right even in the face of Linstow's remarks, and that the correct name is *Moniezia trichoglossi*, Linstow. In his original account, Linstow himself called it a new species, consequently his giving it a binomial name and a description, though short and incomplete, is sufficient ground for retaining his name for the cestode, especially as his types were still available. Had the specimens been lost, then the species might reasonably have been disregarded as not being identifiable from the account. But the re-examination of the types having led to the establishing of identity between it and the later described *M. carrinoi*, the latter name must fall into synonymy.

Order COCCYGES.

Family CUCULIDÆ.

45. *Centropus (Nesocentor) ateralbus*, Less.

Nematoda:—*Filaria sp.*, Linstow, *Arch. f. Naturg.*, XLIII, 1897, p. 284. (Bismarck Archipelago.)

This parasite, a female, was taken from the body cavity of the above mentioned cuckoo.

[1] Linstow, *Centr. f. Bakt.* etc., XXXI, 1902, p. 32.

[2] Fuhrmann, *Zool. Jahrb.*, Suppl. Bd. x, Heft 1, 1908, p. 38.

Order CORACIIFORMES.

(A) Family PODARGIDÆ.

46. *Podargus strigoides*, Lath. (M. 376, H. 437). The tawny frogmouth (More-pork).

Nematoda:—*Filaria sp.*, Bancroft, *Proc. Roy. Soc. Queensland*, VI, 1890, p. 62. (Queensland.)

Bancroft found embryo-filariae (*Micofilaria sp.*) in the blood.

(B) Family CORACIIDÆ.

47. *Eurystomus pacificus*, Lath. (syn. *E. australis*, Swainson). (M. 381, H. 441.) The dollar-bird or roller.

Nematoda:—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Filarial embryos (*Microfilaria*) were seen in the blood.

(C) Family ALCEDINIDÆ.

48. *Dacelo gigas*, Bodd. (M. 386, H. 447). The laughing jackass or brown kingfisher.

Protozoa:—*Halteridium sp.* (N.S. Wales.)

I have seen a blood-film containing this sporozoan.

Trematoda:—*Hemistomum triangulare*, Johnston, (S.J.) *Proc. Linn. Soc. N.S. W.*, XXIX, 1904, p. 108. (N.S. Wales.)

Cestoda:—*Similuncinus dacelonis*, Johnston, (T. H.), *Rec. Austr. Mus.*, VII, 1909, p. 246. (N.S. Wales.)

49. *Halcyon (Sauropliaga) sauropliaga*, Gould. A kingfisher

Trematoda:—*Distomum porrectum*, Braun., *Centr. f. Bakt.*, I, Orig., XXV, 1899, p. 714. (Bismarck Archipelago).

50. *Halcyon (Sauropatis) sanctus*, Vig. and Horsf. (M. 391, H. 452). The sacred kingfisher.

Acanthocephala:—*Echinorhynchus horridus*, Linstow, *Arch. f. Naturg.*, LXIII, 1897, p. 290. (Bismarck Archipelago.)

I have seen a specimen of *Echinorhynchus sp.* taken from this host in New South Wales, but have not examined it sufficiently to be able to compare it with *E. horridus*.

Order PASSERIFORMES.

(A) Family MUSCICAPIDÆ.

51. *Petroeca goodenovii*, Vig. and Horsf. (M. 444, H. 93.) The red-capped robin.

Cestoda :—*Hymenolepis sp.* (Hallett's Cove, South Australia).

Imperfect scolexless fragments were taken by me from a specimen collected by Dr. Cleland.

52. *Myiagra rubecula*, Lath. (syn. *M. plumbea*, Vig. and Horsf.) (M. 488, H. 143). The leaden flycatcher.

Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

This *Microfilaria* was found in the blood.

53. *Myiagra nitida*, Gould. (M. 490, H. 144.) The satin flycatcher.

Protozoa :—*Halteridium sp.*

A sporozoan found by Dr. Cleland and myself in the blood of this bird (N.S. Wales).

(B) Family CAMPOPHAGINÆ.

54. *Coracina sclateri*, Finsch., (syn. *Graucalus sclateri*, Finsch.) A cuckoo-shrike.

Nematoda:—*Diplotriaena tricuspis*, Fedtsch., Linstow, *Arch. f. Naturg.*, LXIII, 1897, p. 283 ; and *Mitth. Zool. Samml. Mus. Naturk.*, Berlin, I, (2) 1899, p. 25. (Bismarck Archipelago.)

This parasite has been taken from the body cavity of *Coracina sclateri*, *Cisticola exilis* and *Calornis metallica*, in the Australian region as well as from a great number of song-birds in other parts of the world. Linstow in 1897 recorded the worm as *Filaria tricuspis*, but in 1905[1] he removed it to the genus *Aprocta*. Quite recently Railliet and Henry[2] have placed the species under *Diplotriaena*.

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[1] Linstow, *Arch. f. Naturg.*, LXXI, 1905, p. 273.

[2] Railliet and Henry, *Bull. Soc. Path. Exotique*, III, 1910, p. 154.

(C) Family TIMELIIDÆ.

55. *Psophodes crepitans*, Lath. (M. 526, H. 223). The coachwhip bird.

Acanthocephala :—*Echinorhynchus sp.*

I have taken specimens from birds collected by Dr. J. B. Cleland (Sydney).

56. *Pomatorhinus frivolus*, Lath. (syn. *Pomatostomus temporalis*, Vig. and Horsf.) (M. 529, H. 226.) The babbler.

Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Microfilaria seen in the blood.

57. *Pomatorhinus superciliosus*, Vig. and Horsf. (syn. *Pomatostomus superciliosus*, Vig. and Horsf.) (M. 530, H. 227.) The white-browed babbler.

Protozoa :—*Halteridium sp.* (Hallett's Cove, Adelaide, S. Australia.)

This parasite has been detected by Dr. Cleland and myself in the red blood corpuscles of this bird. It possesses large pigment granules.

Acanthocephala :—*Echinorhynchus sp.*

Specimens were collected by Dr. Cleland at Hallett's Cove, near Adelaide, South Australia. They were encysted in the subcutaneous tissues of the neck and throughout the body, also in the fascial layer between the thoracic muscles, sometimes deeply embedded, apparently also occasionally in the muscle-substance itself surrounded by a small area of disintegration. This parasite occurs in similar situations in *Pomatorhinus rubeculus* and *Climacteris wellsi* in West Australia, and in *Aphelocephala leucopsis* in S. Australia.

58. *Pomatorhinus rubeculus*, Gould (syn. *Pomatostomus rubeculus*, Gld.) (M. 532, H. 229). The red-breasted babbler.

Acanthocephala :—*Echinorhynchus sp.*

This parasite was identified by me from material collected by Dr. Cleland on the Shaw River in the north-west of West Australia. Their position was remarkable, the worms being embedded in the subcutaneous tissues and in the superficial muscles, reminding one of the Trematode *Monostomum faba*, Bremser, which lives in a similar situation in many passerine birds in Europe.

(D) Family TURDIDÆ.

59. *Oreocichla lunulata*, Lath. (syn. *Geocichla lunulata*, Lath.) (M. 544, H. 160.) The mountain thrush.

Protozoa :—*Halteridium geocichlae*, Cleland and Johnston, *Journ. Roy Soc. N.S.W.*, XLIII, 1909, p. 85. (N.S.W.)

This sporozoon infests the erythrocytes of the blood.

Nematoda :—*Filaria sp. (Microfilaria sp.)*

I have seen filarial embryos in a blood film made by Dr. Cleland. (N.S.W.)

Acanthocephala :—*Echinorhynchus sp.*

A specimen has been identified by me from material collected by Dr. Cleland from the intestine of this bird. (N.S.W.)

(E) Family SYLVIIDÆ.

60. *Cisticola exilis*, Vig. and Horsf. (M. 552, H. 186.) The grass warbler.

Nematoda :—*Diplotriaena tricuspis*, Fedtsch. Linstow, *Arch. f. Naturg.*, LXIII, 1897, p. 283, and *Mitth. Zool. Samml. Mu. Naturk.*, Berlin, I, (2), 1899, p. 25. (Bismarck Archipelago.)

This parasite lives in the body cavity and also infests *Coracina sclateri*, *Calornis metallica*, and other birds, mainly passerines. (See No. 54.)

(F) Family LANIIDÆ.

61. *Gymnorhina tibicen*, Lath. (M. 647, H. 243). The black-backed magpie.

Nematoda ;—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Bancroft recorded the occurrence of embryos in the blood of this host. Dr. Cleland and I have also met with a *Microfilaria* in blood fims from a local bird. (N.S.W.)

62. *Craticus destructor*, Temm. (syn. *C. torquatus*, Lath.) (M. 658, H. 252.) The butcher bird or collared crow-shrike.

Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

The embryos (*Microfilaria*) were seen in the blood, the adults inhabiting the peritoneal cavity.

(G) Family CERTHIIDÆ.

63. *Climacteris wellsi*, Grant.[1] A tree-creeper.

Acanthocephala :—*Echinorhynchus sp.*

This parasite lives in the subcutaneous tissues of the neck of this host. It also occurs in *Pomatorhinus rubeculus*, *P. superciliosus* and *Aphelocephala leucopsis*. The specimens were collected by Dr. Cleland on the Shaw River in the north-western portion of West Australia.

(H) PARIDÆ.

64. *Aphelocephala leucopsis*, Gould (syn. *Xerophila leucopsis*, Gld.) (M. 689, H. 239.) The white-faced titmouse.

Acanthocephala :—*Echinorhynchus sp.* (Hallet's Cove, S. Australia.)

This encysted parasite was collected by Dr. Cleland from the subcutaneous and superficial muscular tissues. It occurs in certain other birds such as *Pomatorhinus* and *Climacteris*.

(J) Family ZOSTEROPIDÆ.

65. *Zosterops caerulescens*, Lath. (M. 712, H. 301). The silver-eye.

Protozoa :—*Halteridium sp.*

This haematozoon has been frequently met with by Dr. Cleland and myself in blood films taken by us from this host (N.S.W.)

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[1] Kindly identified by Mr. Gregory Matthews for Dr. Cleland.

(K) Family Meliphagidæ.

66. *Melithreptus atricapillus*, Lath. (syn. *M. lunulatus*, Shaw). (M. 733, H. 307.) Black-cap, or lunulated honey-eater.

Protozoa :—*Halteridium sp.*

This blood parasite has been seen by Dr. Cleland and myself (N.S.W.)

67. *Ptilotis chrysotis*, Lath. (syn. *P. lewini*, Swainson auct.) (M. 770, H. 329.) The yellow-eared honey-eater.

Cestoda :—*Choanotaenia sp.* (See also No. 69.)

Collected by Dr. Cleland at Milson Island, Hawkesbury River.

68. *Ptilotis chrysops*, Lath. (M. 775, H. 336.) The yellow-faced honey-eater.

Protozoa :—*Halteridium ptilotis*, Cleland and Johnston, *Journ. Proc. Roy. Soc. N.S. Wales*, XLIII, 1909, p. 77.

A blood parasite (N.S.W.)

69. *Ptilotis leucotis*, Lath. The white-eared honey-eater. (M. 778, H. 339).

Cestoda :—*Choanotaenia sp.*

A long thin tapeworm infests *Ptilotis leucotis*, *P. chrysotis*, *Meliornis novae-hollandiae* and *M. sericea*. Its scolex is small and unarmed, but otherwise its characters closely resemble those of the genus *Choanotaenia*. Specimens were taken from *P. leucotis* by Dr. Cleland at Milson Island, Hawkesbury River (N.S.W.).

70. *Ptilotis plumula*, Gould. (M. 787, H. 349). The plumed or yellow-fronted honey-eater.

Protozoa :—*Halteridium sp.*

This haemoprotozoon has been seen by Dr. Cleland and myself in films taken by him from a Western Australian specimen.

71. *Meliornis novae-hollandiae*, Lath. (M. 799, H. 354.) The New-holland or whiskered honey-eater.

Protozoa :—*Halteridium meliornis*, Cleland and Johnston, *l.c.*, p. 85. (N.S.W.)

Cestoda :—*Choanotaenia sp.* (See also No. 69.)

Specimens were collected by Dr. Cleland in Sydney district.

Acanthocephala :—*Echinorhynchus sp.*

I have taken a specimen from the intestine (N.S.W.)

72. *Meliornis sericea*, Gould. (M. 801, H. 356.) The white-cheeked honey-eater.

Cestoda :—*Choanotaenia sp.* (See also No. 69.)

Specimens were collected by Dr. Cleland and myself in the Sydney district and by the former at Hawkesbury River.

73. *Myzantha garrula*, Lath. (syn. *Manorhina garrula*, Lath. (M. 804, H. 360.) Noisy minah or soldier bird.

Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

An adult was found in the peritoneal cavity whilst embryos (*Microfilaria*) were abundant in the bood.

74. *Acanthochoera carunculata*, Lath. (M. 808, H. 363.) The red-wattle bird (gill-bird).

Nematoda :—*Ascaris sp.*, Krefft, *l.c.*, p. 213. (N.S.W. or Queensland.)

Krefft merely stated that Mr. G. Masters had taken *Ascaris* from the eye of this host. The worms are very small and probably belong to the *Filariidae* and not to the *Ascaridae*.

75. *Annelobia lunulata*, Gould (syn. *Acanthochoera lunulata*, Gld.) (M. 811, H. 366.) The little wattle-bird.

Protozoa :—*Trypanosoma sp.*, seen by Dr. Cleland and myself in films kindly forwarded by Dr. Bancroft from Queensland. These films also showed the presence of two different species of *Microfilaria*.

Nematoda—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Embryos (*Microfilaria*) were seen in the blood, an adult being found in the pericardium.

76. *Entomyza cyanotis*, Lath. (M. 813, H. 368). The blue-faced honey-eater.
   Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland,)

Embryos were detected in blood films.

77. *Tropidorhynchus corniculatus*, Lath. (syn. *Philemon corniculatus*, Lath.) (M. 818, H. 370.) The friar-bird (leatherhead.)
   Protozoa:—*Halteridium philemon*, Cleland and Johnston, *l.c.*, p. 81. (N.S.W.)

This haematozoon was described from a local bird.

(L) Family ORIOLIDÆ.

78. *Oriolus sagittarius*, Lath. (syn. *Mimeta viridis*, Lath.) (M. 850, H. 82). The oriole.
   Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Embryos in the blood.

(M) Family DICRURIDÆ.

79. *Chibia bracteata*, Gould. (M. 854, H. 66.) The drongo.
   Nematoda :—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Embryos in the blood.

(N) Family EULABETIDÆ.

80. *Calornis metallica*, Temm. (M. 856, H. 400.) The shining starling.
   Nematoda :—*Diplotriaena tricuspis*, Fedtsch. Linstow, *Arch. f. Naturg.*, LXIII, 1897, p. 283 ; and *Mitth.. Zool. Samml. Mus. Naturk.*, Berlin, I, (2). 1899, p. 25. (Bismarck Archipelago.) (See also No. 54.)

This round worm is known to inhabit many other birds, including *Cisticola exilis* and *Coracina sclateri*.

(O) Family PTILORHYNCHIDÆ.

81. *Chlamydodera maculata*, Gould. (M. 861, H. 167.) The spotted bower bird.

Cestoda:—*Taenia chlamydoderae*, Krefft, *l.c.*, p. 225. New South Wales or Queensland.)

This imperfectly known tapeworm was described as *T. chlamyderae*, this name being evidently derived from the generic name of the host (*Chlamydera maculata* in Krefft). Being a "lapsus calami" it may be altered to *T. chlamydoderae* as Linstow[1] and Fuhrmann[2] have already done.

82. *Sericulus chrysocephalus*, Lewin (syn. *S. melinus*, Lath.) (M. 866, H. 173.) The regent bird.

Nematoda:—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.) Embryos in the bood.

(P) Family PARADISEIDÆ.

83. *Craspedophora alberti*, Masters (syn. *Ptilorhis alberti*, Masters) (M. 870, H. 58.) The Albert rifle bird.

Cestoda:—*Biuterina clavulus*, Linstow, "Entozoa, Challenger Report," Zool., XXIII, 1888, p. 12. (Cape York North Queensland.)

This parasite was imperfectly described by Linstow as *Taenia clavulus*. Blanchard[3] in 1891 thought that this species was probably a *Davainea*. Fuhrmann[4] in 1902 gave a full account of a cestode from certain birds of paradise, which he called *Biuterina paradisea*, making it the type of his new genus *Biuterina*, but in 1908 he[5] stated that his species was synonymous with *Taenia clavulus*, Linst., after having examined the original specimens collected by the Challenger Expedition. This parasite has been taken from several species of birds of paradise. Miss Sweet[1] misquotes Fuhrmann as her authority for stating that *Aporina alba*, Fuhrm. occurs in *Ptilorchis* (sic) *alberti*, whereas Fuhr-

[1] Linstow, "Compend. d. Helm.," Nachtrag, 1889, p. 36.
[2] Fuhrmann, *Zool. Jahrb*, Suppl. Bd. x, (1) 1908, p. 96, p. 179.
[3] Blanchard, *Mem. Soc. Zool. France*, IV, 1891, p. 440; and *Arch. d. Parasitol.*, II, 1899. p. 216.
[4] Fuhrmann, *Zool. Anz.*, xxv, 1902, p. 357.
[5] Fuhrmann, *Zool. Jahrb.*, 1908, *l.c.*, p. 68.

mann[2] states that this Anoplocephalid cestode was taken from a Brazilian parrot, *Pyrrhura sp.*

84. *Paradisea raggiana*, Sclater. Raggi's bird of paradise.
Cestoda:—*Biuterina clavulus*, Linst. Fuhrmann, *Zool. Anz.*, xxv, 1902, p. 357. (New Guinea.)

85. *Paradisea apoda*, Linn. The great bird of paradise.
Nematoda:—i. *Filaria flabella*, Linstow, "Entozoa, Challenger Report," Zool., xxiii, 1888, p. 9. (Aru Islands.]

This parasite was found under the skin and in the abdominal cavity. Linstow[3] mentions that it is the same worm as *Filaria sp.* mentioned by Willemoes-Suhm.[4]

ii. *Filaria paradiseae*, Linstow, *l.c.*, p. 11. (Aru Islands).

86. *Manucodia chalybeata*, Penn. A Manucode.
Cestoda:—*Davainea paradisea*, Fuhrmann, *Centr. f. Bakt.*, i, Orig., xlix, 1909, p. 112. (New Guinea.)

(Q) Family Corvidæ.

87. *Corone australis*, Gould (syn. *Corvus australis*, Gld.) (M. 874, H. 45.) The crow.
Nematoda:—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Embryos were found in the blood, the adults occuring in the peritoneal cavity. Dr. Cleland and I have seen embryofilariae (*Microfilaria*) in blood smears taken from a local bird by Mr. A. R. MacCulloch (N.S.W.).

88. *Strepera graculina*, White. (M. 875, H. 46.) The pied crow-shrike.
Nematoda:—*Filaria sp.*, Bancroft, *l.c.*, p. 61. (Queensland.)

Embryos in the blood.

89. The following parasites have been described from Papuan hosts whose names are not known:—
i. *Davainea appendiculata*, Fuhrmann, *Centr. f. Bakt.*, i, Orig., xlix, 1909, p. 114.
ii. *Davainea echinata*, Fuhrmann, *l.c.*, p. 115.

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1 Sweet, *Proc. Roy. Soc. Victoria*, xxi, (N.S.) 1908, p. 466.
2 Fuhrmann, *Zool. Anz*, xxv, 1902, p. 359; *Centr. f. Bakt.* Orig., xxxii, 1902, p. 135.
3 Linstow, "Comp. d. Helm.," Nachtrag, 1889, p. 37.
4 Willemoes-Suhm, *Zeitschr. f. Wiss. Zool.*, xxxvi, p. 63. †

It appeared to me that it would be of some scientific as well as of economic value to bring together all the references known to me, concerning the occurrence of endoparasites in domesticated and introduced birds in Australia. In addition to those mentioned in the following list, there are others which I have not yet identified. The fact that many of these introduced birds harbour the same tapeworms as in other parts of the world, seems to show that the larval stages have probably accommodated themselves to local intermediate hosts.

90. *Gallus gallus*, L., var. *domesticus*. The domestic fowl.

Protozoa:—*Spirochaeta marchouxi*, Nuttall, (syn. *S. gallinarum*, R. Blanchard). Cleland, *Journ. West. Austral. Nat. Hist. Soc.*, June, 1906; *Rep. Austr. Assoc. Adv. Sci.*, 1907, p. 688; *Journ. Trop. Vet. Sci.*, IV, 1909, p. 495; (West Australia). Dodd, *Rep. Vet. Surgeon, Q'land.* 1908-9, p. 16; (North Queensland). Johnston, *Journ. Roy. Soc. N.S.W.*, XLIII, 1909, p. xvi; (N.S.W.),

This spirochaete is the cause of fowl tick-fever or spirochaetosis (spirillosis). Its real name is perhaps *S. anserina*, Sacharoff, since Galli-Valerio[1] regards both *S. gallinarum*, R. Bl. and *S. marchouxi*, Nuttall to be identical with the earlier described *S. anserina*, which produces a similar sprochaetosis in geese and ducks. Doflein,[2] Nuttall,[3] Lühe[4] and Calkins[5] regard them as different organisms, the last mentioned author placing them both under *Treponema*, and calling the fowl tick-fever organism *Treponema gallinarum*, March. and Salimbeni, 1903. Cleland recorded

[1] Galli-Valerio, *Centr. f. Bakt.*, Orig., L, 1909, p. 198.

[2] Doflein, "Lehrbuch der Protozoenkunde," 2 Aufl., 1909, p. 333.

[3] Nuttall, Warburton, Cooper and Robinson, "Ticks, a Monograph of the Ixodoideæ," Part 1, Argasidae, 1908, p. 8 etc., also p. 85 etc. In a footnote on p 88 of this important work it is stated that *S. gallinarum*, R. Blanch. 1905, is a synonym of *S. marchouxi*, Nuttall, 1904. *S. anserina*, Sacharoff is treated as a different organism (p. 89).

[4] Lühe in Mense's "Handb. d. Tropenkrankheiten," III, 1906, p. 185.

[5] Calkins, "Protozoology," 1909, p. 219.

the spirochaete as *Spirillum sp.*; Dodd, as spirochaetes, and myself as *S. anserina* (*S. gallinarum*). There are some other references to fowl tick-fever (*e.g.* in Agr. Gaz. N.S.Wales), but as the organism is not referred to in any way I have omitted them. The transmitter of the organism in Australia is the so-called "fowl-tick" *Argas persicus*, Oken, (syns. *A. americana*, Packard, *A. miniatus*, Koch), which is reported as being able to inflict serious injuries on human beings[3, 1] in certain parts of the world, *e.g.* Persia. This tick is fairly common in New South Wales, but seems to restrict its action to poultry. Blanchard[2] regards *A. miniatus*, Koch (syn. *A. americana*) as being quite distinct from, though closely allied to, *Argas persicus*.

Trematoda :—*Prosthogonimus ovatus*, Linst. (formerly confused with *Distomum ovatum*, Rud.)

Spencer[3] referred to the presence of small flukes in eggs from Victorian fowls. Though he does not refer to the helminth by name, yet his description evidently refers to the above named parasite. This usually infests the bursa of Fabricius of young birds, and has been occasionally found in the oviduct, and even in the eggs of mature fowls in other parts of the world.[4]

Cestoda:—*Hymenolepis carioca*, Magalh. Johnston, *Proc. Linn. Soc. N.S. Wales*, xxxiv, 1909, p. 599. (N.S.W.)

This delicate tapeworm does not seem to have been previously recognised in Australia. The same remark applies equally to the following species.

ii. *Davainea cesticillus*, Molin. Johnston, *l.c.*, p. 599. (N.S.W.)

iii. *Davainea tetragona*, Molin. Johnston, *l.c.*, p. 599. (N.S.W.)

iv. *Davainea echinobothrida*, Mégnin. Johnston, *Journ. Proc. Roy. Soc. N.S.W.*, xliii, 1909, p. xv. (Fiji.)

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1 Braun, 'Animal Parasites of Man,' Engl. transl., 3rd Edit., 1906, p. 371.
2 Blanchard, " L'Insecte et L'Infection," Fasc. 1, 1909, p. 60, 61.
3 Spencer, *Proc. Roy. Soc, Vict.*, (N.S.) i, 1888, p. 109.
4 Braun, *Centr. f. Bakt.*, xxix, 1901, p. 12-19.

The last reference is to the occurrence of the parasite in Fijian fowls, and is inserted here in order that it may not be overlooked. I have recently recognised the worm in material collected from a hen in the Sydney district. This parasite (*D. echinobothrida*) frequently imbeds its scolex and part of its strombila so deeply into the mucosa and submucosa of the fowl's intestine that it produces a nodule or "tumour" somewhat comparable to those produced by the larvae of the nematode *Oesophagostomum columbianum* Curtice, in the intestinal walls of sheep, and by the larvae of *Oes. radiatum*, Rud. (syn. *Oes. inflatum*, Schn.) which infests the ox, both of these nematodes being commonly met with in these hosts in New South Wales. The condition produced in the fowl is usually called the "nodule disease," or more correctly "nodular Taeniaisis."

v. *Davainea sp.*, Bradshaw, *l.c.*, p. 50. (N.S.W.)

vi. *Choanotaenia infundibulum*, Bloch., (syns. *Taenia infundibuliformis*, Goeze, *Monopylidium infundibulum*, Bl.). N.S. Wales, not previously recorded.

I have now identified these as *D. tetragona*, Molin.

vii. *Cysticercus sp.*, Perrie, *l.c.*, p. 821. (N.S.W.)

I have seen Perrie's specimen, which resembles a hydatid in appearance. I am inclined to regard it as *Echinococcus veterinorum*, Rud. (*E. polymorphus*, Dies.). Brown[1] mentions the occurrence of hydatids in fowls, but does not state whether they occur locally. He[2] also mentions two other tapeworms, viz. *Choanotaenia infundibulum*, Bloch, and *Davainea proglottina*, Davaine, but does not refer to any locality. The latter of these parasites should be omitted from the list of our known entozoan fauna until recognised by some worker in parasitology. The nematodes and cestodes mentioned by Bradshaw as occurring in a fowl were identified by me.

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[1] Brown, *Agric. Journ. Vict.*, I, 1902, p. 698. [2] *Loc. cit.*, p. 698.

Nematoda:—*Ascaris sp.*, Perrie, *Agric. Gaz. N.S.W.*, III, 1892, p. 821. (N.S.W.)

This reference should be to *Heterakis perspicillum.*

ii. *Heterakis perspicillum*, Rud. (syn. *H. inflexa*, Rud.) Cobb, *Agr. Gaz. N.S.W.*, VII, 1896, p. 747 ; *ibid.*, IX, 1898, p. 316; *ibid.*, XVI, 1905, p. 561 (N.S.W.). Johnston, *Proc. Linn. Soc. N.S.W.*, XXXIV, 1909, p. 412. Bradshaw, *Farmers' Bulletin*, No. 15, Dept. Agric. N.S.W., 1909, p. 50.

This large ascarid is fairly common in our fowls though not so abundant as the smaller *Heterakis papillosa*, Bloch.

iii. *Heterakis compressa*, Schneider, *Monogr. d. Nemat.* 1866, p. 71. (South Australia.)

This parasite was described from material collected from South Australian fowls. Both Railliet[1] and Neumann[2] give a summary of Schneider's account. Leiper[6] also refers to it in describing an allied worm *Heterakis numidae*, Leiper, taken from the guinea fowl, *Numida ptilorhyncha*, Licht., in the Soudan. I have taken specimens from a hen in Sydney, which I regard as belonging to this species, as they fully agree with the scanty account given by Schneider.

iv. *Heterakis papillosa*, Bloch., Cobb, *Agr. Gaz. N.S.W.*, VII, 1896, p. 748 (N.S.W.) Johnston, *Proc. Linn. Soc. N.S.W.* XXXIV, 1909, p. 412 (N.S.W.). Bradshaw, *Farmers' Bulletin*, No. 15, Dept. Agric. N.S.W., 1909, p. 50. (N.S.W.)

As mentioned before, this small nematode is very common in local fowls, especially in the caecum. I have also taken it from the caecum of a turkey (vide infra) (N.S.W.)

v. *Heterakis sp.* (N.S.W.)

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[1] Railliet, "Traité de Zoologie médicale et agricole," 2nd edition, 1895, p. 406.

[2] Neumann, "Parasites," Eng. transl. 2nd edit., 1905, p. 409.

[3] Leiper, in "Third Report Wellcome Research Labs.," Khartoum, 1908, p. 193.

Mr. Thos. Steel of Sydney kindly forwarded me a chicken harbouring abundance of nematodes which I have not yet been able to identify specifically.

vi. *Oxyuris sp.*, Perrie, *l.c.*, p. 822. (N.S.W.)

This reference should be to *Heterakis papillosa.*

vii. *Oxyspirura mansoni*, Cobbold (syn. *Spiroptera emmerezii*, Mégnin), Tryon, *Ann. Rept. Entomologist, etc.*, Dept. Agr. Q'land, 1907-8, p. 88 ; Dodd, *l.c.*, 1908-9, p. 20 etc. (Queensland); Johnston, *Journ. Proc. Roy. Soc. N.S.W.*, 1909, p. xv. (Northern N.S.W.)

This tiny worm was formerly known as Manson's eye worm, *Filaria mansoni.* Ransom[1] in 1904, showed that it belonged to the genus *Oxyspirura.*

vii. *Syngamus trachealis*, Siebold, Brown, *Agr. Journ. Vict.*, II, 1904, p. 73, p. 175 (Victoria?). Johnston, *l.c.*, XLIII, 1909, p. xv (N.S.W.)

The "gape-worm" of poultry appears to be rare in Australia. It lives in the trachea, firmly attached to the mucosa. Since the male remains permanently attached to the female, the parasite has often been termed the "forked worm." Mr. E. A. Le Souef, Curator of the Zoological Gardens, Perth, West Australia, informed me that this parasite occurs in fowls and turkeys in that State.

vii. *Dispharagus nasutus*, Rud. (Sydney.)

This filariid was collected by me from the stomach of a fowl sent by Mr. T. Steel. It has not been previously recorded from Australia.

Acarida:—i. *Acarus depilis*, Brown, *Brit. Med. Journ*, II' 1897, p. 1675 (Victoria, South Australia).

This acarid has been recorded from the subcutaneous tissue of poultry. The original description is extremely scanty, the name *A. depilis* being practically a *nomen*

[1] Ransom, "Dept. Agric. U.S.A. Bureau of Animal Industry," Bull, 60, 1904, p. 25.

nudum, but judging from the few points of structure and the habitat mentioned, I think that this parasite is identical with *Cytodites nudus*, Viz.

ii. *Cytodites nudus*, Vizioli, Johnston, *Proc. Linn. Soc. N.S. Wales*, xxxv, 1910 (N.S.W.).

This tiny parasite was found in considerable numbers infesting the mesentery of a local hen. Most members of the *Acarida* (*Acarina*) lead a free or ectoparasite existence, while a few penetrate into the skin, e.g. *Demodex*, *Sarcoptes*, *Psoroptes*, etc. *Sarcoptes* (*Cnemidocoptes*) *mutans*, Robin, the itch mite which produces the disease known as "scaly leg" of poultry, and which occurs in this State,[1] comes under this group. Very few actually pass deeply into the tissues. Examples of the latter group are *Cytodites*, *Falciger* (in certain stages) and others, some of which inhabit the trachea and other passages.

91. *Meleagris gallopavo*, Linn. The turkey.

Nematoda:—i. *Heterakis papillosa*, Bloch., Johnston, *Proc. Linn. Soc. N.S. Wales*, xxxiv, 1909, p. 412. (N.S.W.)

This round worm lives in the caecum of the turkey and fowl.

ii. *Syngamus trachealis*, v. Sieb.

Mr. E. A. Le Souef of the Zoological Gardens, Perth, informed me of the occurrence of the "gape-worm" in Western Australian turkeys and fowls.

Bradshaw[2] regards the disease known locally as "black-head," as the same as that known under this name in the United States, and produced by a protozoan, *Amoeba* (*Entamoeba*) *meleagridis*, Th. Smith. Films taken from the inflamed areas in the intestine and liver and examined by Dr. F. Tidswell, Dr. Cleland, and myself show the presence of very numerous organisms which are probably

[1] Bradshaw, *lc*, p. 78; also *Agric. Gaz. N.S. Wales*, xvii, 1906, p. 125; Rainbow, *Rec. Austr. Mus.*, vi, (3), p. 190. [2] Bradshaw, *l.c.*, p. 99.

A. meleagridis, but the identification is not yet completed. The form of the parasite showed considerably resemblance to a Coccidian, Doflein[1] remarking the same thing in regard to Theobald Smith's figures of it. A more detailed account will be published shortly by the Director in the annual report of the Bureau of Microbiology.

92. *Anas boschas*, Linn. The duck.

Cestoda:—*Hymenolepis sp.*, Johnston, *Proc. Linn. Soc. N. S. W.* xxxiv, 1909, p. 190. (N.S.W.)

The specimens were very small and immature. The scolex was unarmed.

93. *Anser cinereus*, Meyer dom. The goose.

Cestoda :—*Hymenolepis lanceolata*, Bloch., Johnston, *Agric. Gaz. N.S.W.*, xx, 1909, p. 582 ; *Rec. Austr. Mus.*, vii, 1909, p. 331 (N.S.W.).

94. *Columbia livia*, Bonn., dom. The pigeon.

Nematoda :—*Ascaris sp.*, Krefft, *l.c.*, p. 212. (New South Wales or Queensland).

This reference should be to *Heterakis maculosa*.

ii. *Heterakis maculosa*, Rud., Johnston, *Proc. Linn. Soc. N.S.W*, xxxiv, 1909, p 412 (N.S.W.)

Acarida:—*Falciger rostratus*, Bucholz., Sweet, *Proc. Roy. Soc. Victoria*, xxi, (N.S.) 1908, p. 500, 523.

The hypopial stage of this mite was found deeply buried in the subcutaneous tissues.

95. *Passer domesticus*, Linn. The sparrow.

Protozoa:—*Plasmodium passeris*, Johnston and Cleland, Johnston, *Agric. Gaz. N.S. Wales*, xx, 1909, p. 584 ; *Rec. Austr. Mus.*, vii, 1909, p. 344 ; *Jour. Trop. Vet. Sci.*, v, 1910, pp. 353, 357; Johnston and Cleland, *Proc. Linn. Soc. N.S.W.* 1909, p. 507 (N.S.W.)

This sporozoan infests the red corpuscles of the blood. It was first recorded by me as *Plasmodium praecox*, Gr.

[1] Doflein, "Lehrb. d. Protozoenkunde," 2 Aufl., 1909, p. 508.

and Fel.? The differences between *P. praecox* and our forms were thought by us to be of sufficient importance to justify the separation of the latter as a different species *P. passeris.*

Cestoda :—*Monopylidium passerinum*, Fuhrm., Johnston, *Agric. Gaz. N.S.W.*, xx, 1909, p. 584 ; *Journ. Roy. Soc. N.S.W.*, XLIII, 1909, p. 405 ; *Jour. Trop. Vet. Sci.*, v. 1910, pp. 353, 357; Johnston and Cleland, *Proc. Linn. Soc. N.S.W.*, XXXIV, 1909, p. 507 (N.S.W.).

96. *Sturnus vulgaris*, Linn. The starling.

This bird is now very common in the settled districts of New South Wales.

Cestoda :—*Hymenolepis farciminosa*, Goeze.

Some specimens forwarded to me by Mr. S. J. Johnston of the Biology Department, Sydney University, as well as others collected by Dr. Cleland at Berry, belong to the above species. (Sydney, Berry, N.S. Wales.)

97. *Merula merula*, Linn. (syn. *Turdus merula*, Linn.) The blackbird.

This bird has become well established in South and South-eastern Australia.

Cestoda:—*Hymenolepis serpentulus*, Schrank.

This parasite was identified from material collected by Dr. Cleland, near Adelaide (South Australia).

98. *Rhinochetus jubatus*, Verr. and Des Murs. The Kagu.

This is not an Australian bird, since it lives only in New Caledonia. Mr. H. E. Finckh, of Mosman, Sydney, recently forwarded me a dead specimen of this rare bird, and from its intestine I have obtained numerous very small cestodes about 4 mm. long, with well developed suckers and an armed rostellum and alternating genitalia. These have been provisionally determined as *Amoebotaenia sp.*, though the genital organs alternate somewhat irregularly.

ADDENDUM:—The record of *Holostomum sp.* from the gull and jackass mentioned by David (*Jour. Proc. Roy. Soc. N.S W.*, XXXIV, 1900, p. xx.) evidently refers to *Holostomum hillii* from *Larus novae-hollandiae* and *Hemistomum triangulare* from *Dacelo gigas*, respectively, *(vide supra)*.

RECORDS OF THE EARLIER FRENCH BOTANISTS AS REGARDS AUSTRALIAN PLANTS.

By J. H. MAIDEN,

Government Botanist of New South Wales and Director of the Botanic Gardens, Sydney; Diplomé (grande medaille) de la Société Nationale d'Acclimatation de France; Membre Correspondant de la Société Nationale des Sciences Naturelles et Mathématiques de Cherbourg; de la Société d'Horticulture d'Alger, et de l'Union Agricole Calédonienne, Nouméa.

[With Plates III - XV.]

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

"Great geniuses have the shortest biographies. Their cousins can tell you nothing of them. They lived in their work, so their house and street life was trivial and commonplace. Plato, especially, had no external biography. If he had lover, wife or children, we hear nothing of them."—EMERSON.

In the early days of Australian settlement the French Expeditions which arrived in Australasian seas rank next in importance to the British. Between the years 1791 and 1840 no less than seven expeditions of circumnavigation were despatched to these shores, or to the adjacent seas, by the French Government, and the scientific staff of each included one or more botanists or at least a botanical collector, while the publications of each expedition include an account, always enriched by valuable plates, of the plants discovered.

Sir J. D. Hooker[1] gave an admirable statement of these and other expeditions to our shores, but I think the time

[1] "Introductory Essay to the Flora of Tasmania," cxviii-ix ("Outlines of the Progress of Botanical discovery in Australia,—*French*").

has arrived for a more detailed account of the botanical literature of these expeditions and of the botanists who undertook the work of determination and description of the plants. It is a duty we owe to French botanists to recall their labours, while the practical utility of such information requires no emphasis in a company of scientific men.

It will be seen that some of the most brilliant botanists of France have been engaged in the work of the elucidation of the Australian flora, and this remark would be even more true if I had attempted to enumerate the whole of our obligations to French botanists.

For various reasons the whole of the collections brought home by the French expeditions were not fully examined, and it is hoped that, at some convenient time, these remaining specimens will be dealt with by the compatriots of those who often endangered their lives to procure them.

The Australian flora has been elaborated by many botanists[1] of various nations, and I will endeavour, on some future occasion, to give some account of our indebtedness to those other than French and British.

0. 1785-8. "Boussole" and "Astrolabe," commanded by J. F. G. de la Perouse.

This expedition started from France in June 1785, not directly destined for New South Wales, while Governor Phillip and his expedition left England nearly two years later, viz., 13th May, 1787. Governor Phillip arrived in

[1] See also my (1) "Records of Australian botanists" (a. General, b. New South Wales), this *Journ.*, XLII, 60; (2) Notes on South Australian botanists in *Journ. Aust. Assoc. Adv. Sci.*, Adelaide Meeting, 1907; (3) "Records of Victorian botanists," *Vic. Nat.*, XXV, 101; (4) "Records of Tasmanian botanists," *Journ. Roy. Soc. Tas.*, 1909; (5) "Records of Western Australian botanists," *Journ. W. A. Nat. Hist. Soc.*, 1909; (6) "Records of Queensland botanists," *Journ. Aust. Assoc. Adv. Sci.*, Brisbane Meeting, 1909.

Botany Bay on 18th January, 1788, followed by M. de la Pérouse on the 26th (the day on which the British Flag was unfurled in Sydney Cove).

On 10th March la Pérouse sailed out of Botany Bay, and no trace of his expedition was obtained until some wreckage was found in 1825 by Captain Peter Dillon, of H.M.S. "Research" at Vanikoro or Matlikoro, the southernmost island of the Santa Cruz group. This expedition therefore belongs to the pre-settlement era of Australia, and as la Pérouse only touched Australian land on one occasion and later his expedition was wrecked with the loss of all hands, it is evident that an account of it can contain but little of Australian botany. Collections and journals had, however, been sent to France from various other places, and particulars of them and the "instructions" make a valuable volume.

Following is a title-page :—

"A voyage round the world performed in the years 1785, 1786, 1787 and 1788 by the *Boussole* and *Astrolabe*, under the command of J. F G. de la Pérouse. Published by order of the National Assembly under the superintendence of L. A. Milet-Mureau.

In two volumes, illustrated by a variety of charts and plates in a separate volume. Translated from the French, 4 to. London, 1799."

Vol. I, pp. lvi, 539, contains la Pérouse's portrait as frontispiece ; at pp. xxv – lii is a biographical sketch.

On board *La Boussole* were Prévost junior, botanical draughtsman, and Collignon, gardener and botanist.

On board *L'Astrolabe* were De la Martinière, (Bossieu) doctor of physic, medical officer and botanist. He described insects and, as regards plants, the leguminous genus *Bossiaea* was named after him ; Dufresne, naturalist; Père Receveur was a Franciscan friar, "naturalist and doing

the duty of chaplain," (his grave is at La Perouse, Botany Bay near Sydney); Prévost, the uncle, botanical draughtsman.

The instructions to the staff are very copious, and include: Vol. I, Botany, pp. 129-30. "Memoir for the direction of the gardener in the duties he has to perform on his voyage round the world. By M. Thouin, first gardener to the Botanic Garden" (in Paris), pp. 156 – 181. See also "Catalogue of books provided for the voyage" p. 189, Chapters iv-v, Easter Island; v, Sandwich Islands.

Vol. II, contains pp. 529 and index. Chapter xxiii-v deals with Navigators' Islands; Chap. xxvi, Friendly Islands. Norfolk Island. Arrival at Botany Bay.

There is also a folio of "Charts and Plates to la Pérouse's Voyage." These are 69 in number and are very interesting, but the only botanical ones are Nos. 6 and 8, male and female Lianes of Chili; 7 and 9 larger views of the same. There are a number of charts and plants valuable to the student of the South Sea Islands.

We now come to the Australian expeditions proper.

1. 1791-4. "Recherche" and "Esperance," commanded by Bruny D'Entrecasteaux.

This expedition was of considerable importance from a geographical point of view, as the maps of Tasmania and Western Australia abundantly testify. But it is chiefly memorable to Australian botanists from being the means which enabled the genial Labillardière to produce his classical "Novæ Hollandiæ Plantarum Specimen," while the adventure of 'Naturaliste' Riche near Esperance in Western Australia, nearly resulted in tragedy, and he became one of the forerunners of many worthies who have sacrificed, or nearly sacrificed, their lives for the advancement of science in Australia.

Bruny D'Entrecasteaux' flag-ship was the "Récherche." The scientific staff included, *Récherche*, Labillardière, naturaliste; Deschamps, naturaliste; Louis Ventenat, naturaliste, 'faisant les fonctions d'aumônier,' (not to be confused with E. P. Ventenat, see p. 131); Piron, peintre (not to be confused with Péron, see p. 132); Lahaie, jardinier. *Esperance*, Riche, naturaliste (see p. 130); Blavier naturaliste.

Following is a title-page:—

"Rélation du voyage à la recherche de La Pérouse, fait par ordre de l'Assemblée Constituante, pendant les années 1791, 1792, et pendant la 1ère et la 2me année de la Republique Française, par le Cen *Labillardière* . . l'un des naturalistes de l'expedition. 2 vols., 4to Paris (an viii) 1799."

Tome Premier pp. xvi, 442. The following references are especially interesting to Australians:—

Chapitre v, Tasmania. Chapitre vi, New Caledonia. Chapitre ix, South-western Australia. Riche lost. At p. 403 is a reference to "*Eucalyptus cornuta*, Planche 17," which should be 20 (see the folio Atlas below).

Tome II, pp. 332; supplementary pages, Vocabulaires, 1–69; Tables de la route de l'Esperance, 71–99; Table des planches contenues dans l'atlas; 103–8.

Chapitre x, Western Australia; xi, Tasmania; xii, Society Islands; xiii, New Caledonia; xiv, Solomons, Louisiades and New Britain.

Then there is a folio "Atlas pour servir," Paris 1811, consisting of forty-four plates, of which Plates xii (part) and xiii – xxiv are botanical (Tasmania and West Australia), and xl and xli, botanical (New Caledonia).

Then we have:—

"Voyage in search of La Pérouse performed by order of the Constituent Assembly, during the years 1791, 1792, 1793 and

1794, and drawn up by M. Labillardière." Translated from the French, illustrated with 46 plates (reduced to 8vo size from the preceding work). London, 1800, 4to, pp. 476 with an Appendix of 65 pages.

Bearing in mind the industry and eminence of Labillardière, we cannot but regret that his opportunities for collecting in Tasmania and the mainland were so limited. Following is an account of him :—

Labillardiere, Jacques Julien Houton de (1755 – 1834). Born at Alençon, studied medicine and botany at Montpellier, and graduated at Paris, 1780. Visited England, Switzerland, and Italy. In 1786 he visited the Levant, and on his return published *Icones Plantarum Syriæ rariorum descriptionibus et observationibus illustratæ.* Lutetiae Parisiorum (Parisiis), 1791 – 1812. 4to. V decades. (See also Willdenow's "Principles of Botany," English trans. 2nd Edit. p. 494). He then came with D'Entrecasteaux' expedition. Author of *Novæ Hollandiæ Plantarum Specimen*, 2 vols. 4to, Paris, 1804-6; *Sertum Austro-Caledonicum*, 4to Paris, 1825, which with the "Relation" contain the results of his researches and observations in Australasia and the East Indies. Died at Paris. Lithograph 1821, by Julien L. Boilly. [See Plate 3.] (1), with a few unimportant additions.

"Lorsque la discorde eut mis fin à l' expédition d'Entrecasteaux, et que les collections de M. de la Billardière furent transportées en Angleterre, il réussit à se les faire remettre; et non seulement il s'empressa de les renvoyer ici, il ajouta à tant de soins la délicatesse de les renvoyer sans même les avoir regardées : il aurait crainte d' enlever, écrivait il à M. de Jussieu, une seule idée botanique à un homme que était allé les conquérir au péril de sa vie. Dix fois des collections addressées au Jardin du Roi, et prises par des vaisseaux anglais, furent recouvrées par lui et rendues de la même

manière." [His other services to French scientific men during those troublous times were then enumerated.] Extract from Cuvier's Eulogy on Sir Joseph Banks, read 2nd April, 1821. (*Mémoires de l'Institut*, 1821 p. 224.)

The following Australian plants were named after him:

Brathys Billardieri, Spach, = *Hypericum gramineum*, Forst.; *Colobanthus Billardieri*, Fenzl.; *Hibbertia Billardieri*, F.v.M.; *Nitraria Billardieri*, DC. = *N. Schoberi*, L.; *Phebalium Billardieri*, A. Juss.; *Rœpera Billardieri*, A. Juss. = *Zygophyllum Billardieri*, DC.; *Trymalium Billardieri*, Fenzl.; *Turræa Billardieri*, A. Juss. = *T. pubescens*, Hellen; *Bauera Billardieri*, D. Don = *B. rubioides*, Andr.; *Eucryphia Billardieri*, Spach.; *Phyllota Billardieri*, Benth. = *P. phylicoides*, Benth; *Apalochlamys Billardieri*, DC. = *Cassinia spectabilis*, R. Br.; *Brachycome Billardieri*, Benth.; *Calythrix Billardieri*, Schau. = *C. tetragona*, Labill.; *Epilobium Billardierianum*, Ser.; *Lagenophora Billardieri*, Cass.; *Marquisia Billardieri* A. Rich. = *Coprosma Billardieri*, Hook. f.; *Senecio Billardieri*, F.v.M. = *Bedfordia linearis*, DC.; *Siebera Billardieri*, Benth.; *Styphelia Billardieri*, F.v.M. = *Cyathodes glauca*, Labill.; *Obione Billardieri*, Moq. = *Theleophyton Billardieri*, Moq. = *Atriplex Billardieri*, Hook. f.; *Rhagodia Billardieri*, Br.; *Adriana Billardieri*, Baill. = *Trachycaryon Billardieri*, Kl. = *Adriana quadripartita*, Gaudich; *Leptomeria Billardieri*, Br.; *L. Billardieri*, Sieb. = *Choretrum Candollei*, F.v.M.; *Phyllocladus Billardieri*, Mirb. = *P. rhomboidalis*, Rich.; *Agrostis Billardieri*, Br. = *Deyeuxia Billardieri*, Kunth.; *Desvauxia Billardieri*, Br. = *Centrolepis fascicularis*, Labill.; *Festuca Billardieri*, Steud. = *Agroporum scabrum*, Beauv.; *Grammitis Billardieri*, Willd. = *Polypodium australe*, Metten.; *Lycopodium Billardieri*, Spreng. = ?; *Pentapogon Billardieri*, Br.; *Phymatodes Billardieri*, Presl. = *Polypodium Billardieri*, Br. = *P. pustulatum*, Forst.: *Poa Billardieri*, Steud.; *Schedonorus Billardieri*, Nees = *S. littoralis*, Beauv.; *Tmesipteris Billardieri*, Endl. = *T. tannensis*, Bernh.; *Phaceolocarpus Labillardieri*, J. Ag. (Figured in Harvey's *Phycologia Australica*).

Riche, Claude Antoine Gaspar (1762–1797). Born at Chamelet en Beaujolais, 20th August, 1762, educated at Lyons and Montpellier but did not finish his studies through ill-health. He died 5th September 1797 at Mont d'or, where he had gone to take the waters. He had not put his papers in order, and left an unpublished work "Chimie des végétaux." He was a botanical collector, but did not write on botany. He was more interested in entomology, and was a correspondent of Fabricius (2) Tome 39 (1824). He was "Naturaliste" on the "Esperance," and helped with the botanical collections.

Allan Cunningham gives an excellent account of Riche under t. 3251, *Bot. Mag.*, from which the following particulars are abstracted.

He begins with an extract from Robert Brown's MSS. in regard to the variability of *Leucopogon Richei*, R. Br. He then points out that the name has reference to a tale of distress and privation to which M. Riche was subjected in December, 1792. D'Entrecasteaux' ships anchored amongst the islands named after one of them Récherche Archipelago. The discoveries made by Nuyts in 1627 on the South Coast had terminated at that Archipelago, and it does not appear that either the Dutch, or Vancouver a century and a half later, effected a landing, so that our earliest knowledge of the vegetation of this portion of "Nuyts' Land," slight as it was, was due to M. Riche and his misfortune.

We learn from Labillardière that a boat had been sent from L'Esperance (the modern Esperance) to the "main shore," and M. Riche accompanied the party. Quitting the beach on which he had landed, (some miles to the westward of Cape le Grand, in long. 121¼° E.), he lost his way while botanising.

M. Labillardière formed one of a search party and they traced M. Riche to the shores of a salt lake (Lake Warden presumably—J.H.M.) near Esperance. They finally found him after an absence of 54 hours, and he had been almost without food, his slender supply being eked out with fruits of the shrub now known as *Leucopogon Richei.* It is figured at t. 3251.

Riche had lost all his specimens, but Labillardière made a collection in the search after him, his specimens including *Leucopogon Richei*, *Banksia repens* and *nivea*, *Chorizema ilicifolia*, *Eucalyptus cornuta* and *Anigozanthus rufa.*

Labillardière wrote later that Riche died from consumption on his return to France, having, while ill, undertaken a long and fatiguing journey in the cause of science.

Besides the plant referred to, he is commemorated by the genus *Richea*, R.Br., and *Craspedia Richea*, Cass.

Ventenat, Etienne Pierre. I cannot find that the companion (Louis) of Labillardière, although a "naturaliste," was a botanist, but Etienne Pierre (1757—1808), librarian of the Pantheon at Paris and member of the National Institute, was author of several works dealing with plants brought home by, or raised from seeds brought home by D'Entrecasteaux' or Baudin's Expeditions. For example:

"Description des plantes nouvelles cultivées dans le jardin de J. M. Cels. Paris (1800). 4to; (2) Tableau du règne végétal, etc. Paris (1799). 4 vols. 8vo; (3) Choix des plantes . . . , dans le jardin de Cels. Paris, 1803, fol.; (4) Jardin de la Malmaison, etc. Paris, 1803(-4), 2 vols. fol.; (5) Decas generum novorum aut parum cognitorum. Parisiis, 1808, 8vo. In this work he founded the genus *Callitris.*

The following plants bear his name:—

Eugenia Ventenatii, Benth.; *Frenela Ventenatii*, Mirb. = *F. rhomboidea*, Endl.

2. 1800-1804. "Geographe," "Naturaliste," and "Casuarina," commanded by Nicholas Baudin.

There was no Labillardière on this expedition, and the natural history results were chiefly zoological. The botanical collections were incorporated in the Paris herbarium, and, instead of being described as a whole, some of them were examined by monographers at odd intervals for many years afterwards, and we lack, even yet, a full account of them. Leschenault appears to have allowed his travels in other parts of the world to have crowded out thoughts of Australian plants. He however, published but little on scientific subjects. Besides his brochure on Australian plants, he published a short account of the Cinnamon tree.

As far as Australian plants are concerned, this expedition visited, (1) The islands of the north-west and west coasts of Western Australia, also the south coast of Western and South Australia (overlapping Flinders). (2) King Island, Bass' Straits. (3) Port Jackson.

In October 1800 the expedition left Havre, and the "Geographe" was Baudin's flag-ship. The "Naturaliste" had Captain Hamelin in command, while the "Casuarina" was commanded by Lieutenant Louis Claude Desaulces de Freycinet. F. Péron and Lesueur were the zoologists and Leschenault de la Tour was botanist. Anselme Riedlé was head-gardener (jardinier-en-chef). He died at Timor, 21st October, 1801. *Cycas Riedleyi*, Gaud. (=*Macrozamia Fraseri*, Miq.), was named after him. Antoine Sautier was gardener (garçon jardinier) of this expedition, and died at sea, 15th November, 1801. Antoine Guichenot was also gardener, but I have no further details concerning him.

A. Michaux (afterwards author of "Sylva Americana") and J. Delisse also embarked on this expedition, but left it at the Isle of France on the outward voyage. Bory de St.

Vincent, afterwards eminent as a botanist, embarked as zoologist, and was also left at the Isle of France. See pp. 139 and 142.

The following work is from the pen of **Bory de St. Vincent** (Jean Baptiste M.A.G.):—

"Voyage dans les quatre principales iles des mers d'Afrique, fait par ordre du gouverenment pendant les années ix et x de la Republique (1801 et 1802), avec l'histoire de la traversée du Captain Baudin jusqu'au Port Louis de l'isle Maurice." Paris, 1806, 3 vols. atlas of 58 plates in 4to.

The most important work relating to Baudin's expedition is:—

"Voyage de découvertes aux Terres Australes . . . rédigé par M. F. Péron, Naturaliste de l'Expedition etc." 1st vol. 4to Paris, 1807. 2nd vol. edited and continued by Louis Freycinet, 1816 (after Péron's death).

This work treats in the most cursory way of the plants. Nevertheless, the following itinerary taken from it is valuable to those who study the plants brought home by the expedition.

Livre ii, Chap. v. Voyage from Isle of France to New Holland. Terre de Leuwin (King George's Sound to Cape Leuwin), 25th April to 19th June, 1801; Terre d'Endracht (Shark's Bay) 19th June to 12 July, 1801. Chap. vi. Terre de Witt (South of King Sound) 23rd July to 18th August, 1801. Chap. ix. Opérations du Naturaliste à la Terre d' Edels (Victoria district) 8th June to 16th July, 1801. Chap. x. Opérations du Naturaliste à la Terre D'Endracht, 16th July to 21st September, 1801.

Livre iii, Chap. xv. Terre Napoléon (South coast of Western Australia and South Australia), 29th March to 8th May, 1802. Chap. xix. At Port Jackson (20th June to 18th November, 1802.

Vol. II, Livre iv, Chap. xxiv. Retour à la terre Napoléon: Ile Decrès (Kangaroo Island), 27th December, 1802 to 1st February, 1803. Chap. xxv. Golfes de la terre Napoléon: Port Champagny.

1st January to 2nd February, 1803. Chap. xxvi. Suite de la terre Napoléon. Séjour aux iles Joséphine, 1st to 17th February, 1803. Chap. xxvii. Opérations à la terre de Nuyts. Séjour au port du Roi George (King George's Sound), 11th February to 8th March, 1803. Chap. xxix. Terre de Leuwin: Retour à la terre d'Edels, 7th to 16th March, 1803. Chap. xxx. Fresh stay at D'Endracht's Land, 16th to 26th March, 1803. Chap. xxxi. Second stay at terre de Witt: "Nouvelle reconaissance de l'archipel. Bonaparte," 27th March to 28th April, 1803. Chap. xxxiii. Last operations at terre de Witt, 3rd June, 1803. Chap. xxxviii. "Notice sur la végétation de la Nouvelle Hollande par M. Leschenault," pp. 358 to 372.

Leschenault de la Tour, Louis Theodore (1773–1826). Born 13th November, 1773 at Châlons-sur-Saône, son of a procurator of the King. He joined the "Naturaliste," at Timor 7th October, 1801; the "Geographe" at Port Jackson 3rd November, 1802, and was left sick at Timor, 2nd June, 1803. He explored Java and also Philadelphia before returning to France in July, 1807. Between 1816 and 1822 he was at the Cape de Verde Islands, Cape of Good Hope, India, Ceylon and the Island of Bourbon, returning to the Cape of Good Hope in May, 1822. In 1823-4 he was in Brazil and British Guiana, returning home in 1824. He died 14th March, 1826. He wrote a sketchy "Notice" of the Australian vegetation for Péron's work, which should be translated.[1]

Urban in Martius' Flora of Brazil, Vol. I, Part 1, quotes the following bibliography concerning him:—

"J. Eugène Deschamps: Jean-Baptiste-Louis-Claude-Théodore Leschenault de la Tour in Didot *Nouv. Biogr. génér.* vol. xxx, (1859) p. 923–927. E–s: Louis Théodore Leschenault de la Tour in Michaud *Biogr. univ.* vol. XXIV, p. 294 Lasègue *Mus.*

[1] See my note in *Proc. Aust. Ass. Adv. Science*, Adelaide Meeting, (1907) page 166.

Delessert (1845) p. 271 – 275, 430 – 432. *Bull. Soc. Sciences Saône et Loire*, II, (1884) p. 123 - 158, cum indice operum (n.v.). Pritz. *Thes.* ii ed p. 182; *Cat. Sc. Pap.*, III, p. 967, VI, p. 712, XII, p. 442."

In Western Australia, Cape Leschenault, near the Moore River, and Leschenault Estuary near Bunbury are named after him, while the remarkably beautiful Goodeniaceous genus *Leschenaultia* bears his name, also *Hemistemma Leschenaultii*, DC. = *Beyeria Leschenaultia*, Baill. = *B. opaca*, F.v.M.; *Indigofera Leschenaultia*, DC. = ?; *Calythrix Leschenaultii*, Schauer.

Desfontaines, Rene Louiche (1752 – 1833). Born at Tremblay in Brittany, 14th February, 1752, died at Paris, 16th November, 1833. In 1786 he was appointed professor of botany in the Jardin des Plantes, and was several times Director of the Natural History Museum, at Paris. Elected in 1783 to the Academy of Sciences, he contributed many valuable papers to its *Transactions*, among them his celebrated memoir on the structure of moncotyledons, 1796 (1).

Works which specially interest Australians are :—

(1) Mémoire sur le genre *Anthistiria*, etc. (*Journ. Phys.*, xl), Paris, 1792, 4to.

(2) Tableau de l' école de botanique du Muséum d' histoire naturelle, Paris, 1804, 8vo; Ed. 2 (du jardin du roi) *ib.* 1815, 8vo; Ed 3 (Catalogus plantarum horti regii parisiensis), Parisiis, 1829, 8vo. [This work contains names for various species of Eucalyptus not now maintained. It also contains other selections from the Western Australian plants collected on Baudin's expedition.]

The genera *Fontanesia* and *Louichea* were dedicated to him. Line and stipple engraving, ad vivium 1824, by Ambroise Tardieu. Bust (in an oval), face three-quarters to the right. [See Plate 5.] (1)

Bonpland, Aime Jacques Alexandre (1773 – 1858). Born at La Rochelle, 29th August, 1773. Studied botany and medicine, but his studies were interrupted by the troublous times. Introduced to Humboldt and went to America with him and collected and dried "more than 6,000 new plants." Visited Venezuela, Cuba, New Granada, Peru, Mexico (1799 – 1804). Napoleon gave him a pension and the Empress Josephine accepted rare American seeds for her garden at Malmaison from him. The post of "Intendant" of her garden being vacant, Bonpland was appointed and remained until 1804-15. Author of "Descriptions des plantes rares cultivées à Malmaison et à Navarre," Paris 1813, Folio, 157 pages and 64 coloured plates (published in 11 parts). This beautiful work treats of the following Australian plants, mostly raised from seed brought home by Baudin's expedition:—

Metrosideros (Callistemon) saligna, Goodenia grandiflora, Melaleuca chlorantha, Gompholobium furcellatum, Correa viridiflora, Eucalyptus diversifolia, Acacia linifolia, Pittosporum tomentosum, Zieria Smithii, Tristania neriifolia, Pimelea linifolia, Metrosideros (Callistemon) glauca, Chorizema ilicifolia, Metrosideros (Callistemon) pallida, Acacia subulata, Banksia marcescens, Elæocarpus acuminatus, Hovea Celsi, Bossiæa coccinea, Duvalia oxalidifolia, Acacia armata. There is no preface.

Emigrated to the Argentine, 1816, starting a medical practice at Buenos Ayres. Cultivated Maté at Santa Anna, was imprisoned by the Dictator of Paraguay (Francia) from 1821-31, it being alleged that he was a French spy. He emigrated to Brazil (Rio Grande do Sul), and thence to Uruguay, later in 1853 to the Corrientes province, where he was Curator of the Natural History Museum. He died 11th May, 1858, at San Francisco de Borja (Corrientes).

Besides the Malmaison work already referred to, he cooperated with Humboldt in various botanical works con-

cerning South America. The Australian *Hydrocotyle Bonplandi* A. Rich.=? commemorates him.

Jussieu, Adrien de (1797 – 1853). Born 23rd December, 1797, died at Paris 29th June, 1853. Professor of Botany at the Jardin des Plantes 1826, professor at the Sorbonne, 1845. Described some of the plants brought home by Baudin's Expedition together with some from other Australasian expeditions, in the following:—

(1) "Considérations sur la famille des Euphorbiacées." (*Mémoires du Muséum d' hist. nat.*, x, 1823) pp. 39.

(2) "Mémoires sur les Rutacées" etc. (*Mém. Mus. Hist. Nat. Par.*, xii), Paris, 1825, 4to pp. 160, 16 tab.

(3) "Monographie du genre Phebalium." (*Mém. de la Soc. d' hist. nat. de Paris*, tome ii, 1825) pp. 13, 3 tab.

(4) "Mémoires sur la groupe des Méliacees." (*Mém. du Mus. d' hist. nat*, xix, 1830) 152, pp. 12 tab.

3. 1817-20. "Uranie" and "Physicienne," commanded by Louis de Freycinet.

This expedition visited Port Jackson and Gaudichaud was the first French botanist of these expeditions to botanise in the Blue Mountains and Bathurst, which he did on a brief journey, with the assistance of Cunningham and Fraser. The botanical works of this expedition are not numerous, but they include Gaudichaud's fine work (as principal contributor) and a splendid folio atlas of 120 plates, including some Australian plants.

Following is a title-page :—

"Voyage autour du monde, entrepris par ordre du Roi . . . et conformement aux instructions de Son Exc. M. le Vicomte du Bouchage, . . . executé sur les Corvettes de S.M. *l'Uranie* et *la Physicienne* pendant les années 1817, 1818, 1819 et 1820. Publié sous les auspices de Son Exc. M. le Comte Corbière, . . . pour la partie historique et les sciences naturelles, et de S. Exc. le Comte

Chabrol de Crouzòl, . . . pour la partie nautique ; Par M. Louis de *Freycinet*, Capitaine de Vaisseau, ... commandant de l'expedition. *Navigation et Hydrographie.*" Atlas, Paris, 1826.

This folio work is valuable to the botanist for the specific localities of plants collected.

Port Jackson, Botany Bay, the Blue Mountains (New South Wales) and Shark's Bay ("baie de Chiens") in Western Australia were visited, and a minute geographical survey was made of Shark's Bay. More or less exploring was done off the west and north-west coasts.

The 4to vol. of text (Botany) has a similar title-page and date, except that it has for sub-title " Botanique, par M. Charles Gaudichaud, Pharmacien de la Marine," pp. vii, 522. He gives acknowledgments to "MM. Desfontaines, Jussieu, pere et fils, Deleuze, Kunth."

Chap. vii, pp. 33 – 37, "Nouvelle Hollande, Baie des Chiens Marins " (Shark's Bay).

Then there are chapters on various South Sea Islands,— very useful. Chapter xvi, p. 108, "Nouvelle Hollande (Port Jackson, Botany Bay, Montagnes Bleues, Bathurst, etc.)." This chapter should be translated and published. Gaudichaud of course followed the old road to Bathurst described in the paper of myself and Mr. Cambage.[1] Then we have a valuable list of species, arranged in botanical sequence, with localities at end of each species.

This volume of text in which Gaudichaud received the assistance (in addition to those already acknowledged), of Christian Heinrich Persoon for Lichens and Fungi, of Carl Adolph Agardh for Algæ, and Christian Friedrich Schwaegrichen for Mosses and Hepaticæ, was accompanied by a folio atlas of 120 plates by Poiret fils. (Paris, 1826).

[1] This Journal, Vol. XLIII, p. 123.

Gaudichaud-Beaupre, Charles was born in Angoulème, 4th September 1789, and died in Paris, 16th January, 1854. He was a "Pharmacien de la 1e Classe de la Marine," and professor of botany. He accompanied the present expedition as pharmacien-botaniste.

The official botanical publications of this expedition already referred to are an important contribution to science, while his other works include "Mémoire sur les Cycadées" (1824-5), "Notice sur les genre *Adriana*" (1825). Most of his papers are, however, on physiology or morphology. Biographical accounts of him will be found in (**2**), (**3**), (**4**).

The following plants were named after him:—

Commersonia Gaudichaudii, J. Gay; *Philotheca Gaudichaudi*, G. Don. = ?; *Stephania Gaudichaudi*, A. Gray = ?; *Galium Gaudichaudi*, DC.; *Hydrocotyle Gaudichaudiana*, DC. = ?; *Sambucus Gaudichaudiana*, DC; *Senecio Gaudichaudianus*, A. Rich.; *Enchysia Gaudichaudii*, Presl. = ?; *Laurentia Gaudichaudi*, A. DC. = ?; *Grevillea Gaudichaudii*, Br.; *Plantago Gaudichaudii*, Barn. = ?; *Rhagodia Gaudichaudiana*, Moq; *Trichinium Gaudichaudii*, Stew. = *T. corybosum*, Gaudich; *Adriana Gaudichaudi*, Baill. = *A. tomentosa*, Gaudich.; *Carex Gaudichaudiana*, Kunth. = *C. vulgaris*, Fries, var. *Gaudichaudiana*, Boott; *Freycinetia Gaudichaudii*, Benn.; *Isolepis Gaudichaudiana*, Kunth. = *Scirpus Gaudichaudi*, Bœckel = *S. inundatus*, Spreng.; *Polypodium Gaudichaudii*, Bl. = *P. rigidulum*, Swartz.

4. 1822-5. "Coquille," commanded by L. J. Duperrey.

The renowned **D'Urville** was a member of this expedition as he was also of the three subsequent ones. **Bory de St. Vincent** (see Baudin's expedition), again comes on the scene. Two fine illustrated works depict the floral treasures which are invaluable, in spite of the careless editing of one volume of plates, which has caused some little trouble to bibliographers and botanists. This expedition gave special attention to the Algae.

Following is a title page of what we may term Vol. I, (Cryptogams), although it has not a number :—

"Voyage autour du Monde, exécuté par ordre du Roi, sur la Corvette de Sa Majesté *La Coquille*, pendant les années 1822, 1823, 1824 and 1825, sous le ministère et conformément aux instructions de S. E. M. le Marquis de Clermont-Tonnerre, . . et publié sous les auspices de Son Excellence M. Le Cte de Chabrol . . . . par L. I. Duperrey, ... Commandant de l'expedition" *Botanique*, par MM. D'Urville, second de l'expedition, Bory de St. Vincent et Ad. Brongniart.

Cryptogamie, par M. Bory de St. Vincent, 4to pp. 301, Paris, 1828. Introductory pp. 1–61; Agamie (Algae) 62–242; Lycopodiaceæ 244–249; Filices 249–285. A useful "Table des Matières" at pp. 287–298 and Table des planches, pp. 299-300, necessary for bibliographers.

The corresponding Atlas (*i.e.*, Cryptogams) published (or at least dated) two years before, *i.e.*, in 1826, has practically the same title-page. Its sub-title is "Histoire Naturelle, botanique," Folio, 39 plates; Paris, Arthur Bertrand, 1826. The plates are marked 1–38, 13 bis. Plates 1–24 (*i.e.*, 25 plates) are coloured, and consist of Algae; plates 25–38 are uncoloured and consist of Lycopodiaceae and Filices. See also the following work by Bory de St. Vincent :—

"Histoire des Hydrophytes, ou plantes agames des eaux, récoltées par MM. D'Urville et Lesson dans leur voyage autour du monde sur *la Coquille* pendant les années 1822–1825, sous le commandement du Capitaine Duperrey," Paris, 1829, folio, 240 pp., 24 tabl. col.

This is a separate account of the Algæ, but I have not seen it.

In the introduction to Vol. I (Cryptogams, already referred to) at page 7 the following passage occurs :—

. . . "c'est par elles que nous commencerons le catalogue des richesses botaniques dues au zèle infatigable de MM. d'Urville et Lesson."

At p. 2 of the introduction to Vol. II (Phanerogams), we have—

"La plus grand partie des collections botaniques est due à M. d'Urville: mais nous avons réçu aussi de M. Lesson, médicin de l'expédition, un grand nombre d'échantillons, dont plusiers n'existaient pas dans l'herbier formé par M. d'Urville, et dont les autres ont souvent complété nos materiaux."

Vol. II (Phanerogams) is also not numbered, and has the same title-page as Vol. I, except that it has for sub-title "Phanerogamie, par M. Ad. Brongniart." Paris, 1829, 4to pp. 200, (according to the Botanic Gardens and Mitchell Library copies, but Hooker *op. cit.* and Pritzel say 232, while the copy of the Public Library of N.S.W. has that number of pages).

The work is mainly devoted to grasses, as the following will show:—Grasses, pp. 1–148; Cyperaceæ, 149–182; Juncaceæ, 183-4; Bromeliaceæ, 185-7; Orchidaceæ, 188–205; then Dicotyledons, Urticaceæ 206–216; Euphorbiaceæ, 217–228; Santalaceæ, 228–232. The work ends abruptly at p. 232, at an incomplete description of Planche LII A. Probably further sheets were printed off, or at all events additional material was got ready for the press, and I hope French botanists will endeavour to complete this valuable work or inform us where the missing pages are.

The Australian plants were all collected at Port Jackson. Specimens were also collected in the Society Islands, Caroline Islands, Islands near New Guinea, New Zealand.

There is an Atlas of folio plates for Phanerogams as for Cryptogams. Speaking of the Phanerogam atlas, Pritzel says there are 78 plates. He adds "Opus nescio qua negligentia adhuc incompletum desinit in verbis "au sommet" —in tabularum ordine desunt 23, 55, 57, 58, 63, 65, 66, 67, 72, 73, 74, 76."

I have collated the Botanic Gardens copy and note Pritzel's remarks. All the plates are uncoloured. No. 23 is missing. There are two plates 30 (*Hierochloe antarctica*, var. *redolens*, and *Carpha arundinacea*). All the other plates are missing as enumerated by Pritzel.

D'Urville, Jules Sebastien Cesar Dumont (1790—1842). Circumnavigator and botanist. Born 23rd May, 1790, at Condé sur Noireau, Calvados, and was killed on 12th May, 1842, in a train which caught fire between Paris and Versailles. There is an account of his life in *Tas. Journ.* II, 75. A list of his works will be found in (2) and includes:—

Mémoires sur la flore des îles Malouines; Mémoire sur la distribution géographique des fougères à la surface du globe. (*Ann. Sc. nat.* t. 6, p. 51, 1835); Reports on the voyage of the "Astrolabe" (1829) and of the "Astrolabe and Zélée" (1840).

He was an indefatigable collector as well as a cryptogamic botanist. See also Expeditions (5) and (7).

The following plants bear his name:—

Quinetia Urvillei, Cass.; *Centrolepis Urvillei*, Hieron = *Desveauxia Urvillei*, Steud. = *Centrolepis Drummondii*, Hieron; *Eragrostris Urvillei*, Steud. = ?; *Eurostorrhiza Urvillei*, Steud. = *Caustis pentandra*, R. Br.; *Gahnia Urvilleana*, Kunth. =?; *Isolepis Urvillei*, Steud. = *Scirpus Urvillei*, Bœckel = *S. inundatus*, Spreng.; *Plinthanthesis Urvillei*, Steud. = ?; *D'Urvillæa potatorum*, Aresch. (figured in Harvey's *Phycol. Australica*).

Bory de St. Vincent, Jean Baptiste George Marcellin, Baron de (1778 - 1846). Already alluded to at pp. 133, 139. Born at Agen, 6th July, 1778. Went on a geological journey to Bourbon (1798 - 1802). Entered the Institut as Member of the Academy of Sciences in 1832. Went on a botanical journey to Algeria 1840-2. Died at Paris, 23rd December, 1846. A cryptogamic botanist mainly. Some interesting letters from Bory de St. Vincent when in

Algeria are given *in extenso* at XCIII – CI, *Bull. Soc. Bot., France*, Vol. 58 (1909), and M. Ed. Bonnet has annotated these in an interesting manner with particulars concerning the writer and contemporary botanists.

Brongniart, Adolphe Theophile [son of Alexandre Brongniart, also a botanist] (1801 – 1876). Born at Paris, 14th January, 1801, graduated doctor of medicine in 1826. A distinguished botanist, he wrote chiefly on palæontology and vegetable physiology. His works include:—"Enumération des genres de Plantes cultivées au Muséum d'histoire naturelle de Paris suivant l'ordre établi dans l'école de botanique en 1843." Paris 1843, 8vo pp. xxxii, 136. Works in *Ann. de Sc. nat.*, *Ann. du Mus. d'histoire nat.* He died 18th February, 1876 at Paris. There is a short obituary notice concerning him in the "*Gardeners' Chronicle*" for 26th February, 1876, p. 274.

5. 1826-9. "Astrolabe," commanded by J. Dumont D'Urville.

M. D'Urville commanded this expedition, and with M. Lesson, a well known zoologist, also gave some attention to the plants, as they did on the "Coquille." The "Astrolabe" visited Port Jackson, and also voyaged amongst the Line Islands.

M. D'Urville planned the publication of the scientific results of this expedition on adequate lines. Again he and M. Lesson co-operated. The botanical results are more valuable to New New Zealand than to Australia, but there are a number of Australian plants described, some of which were given to M. Lesson by Mr. Fraser, then Superintendent of the Sydney Botanic Gardens.

The results of the voyage of the "Astrolabe" were published in 12 octavo volumes. That of Botany forms the "Deuxième Division" and is described "Botanique. Texte

de MM. Lesson jeune et A. Richard ; 1 volume grand in 8; atlas de 80 Planches au moins en taille-douce, la plupart colorées, sur demi-feuille jésus-vélin."

Of No. 1 (Botany) the title-page is "Voyage de découvertes de l'Astrolabe, exécuté par ordre du Roi, pendant les années 1826, 1827, 1828, 1829, sur le commandement de M. J. Dumont D'Urville. Botanique par MM. **A.** (? **R. P.**, J.H.M.) **Lesson** et **A. Richard.** Paris, J. Tastu Editeur, 1832."

This contains 376 pages, and is entirely devoted to New Zealand botany. No. 2 has a similar title-page, except that the author is A. Richard, and the date of publication 1834. It consists of 167 pages.

This second part is styled *Sertum Astrolabianum* and is a description of species collected by "*M. Lesson* jeune, Chirurgien de la Marine Royale." The plants described are from various groups of Pacific Islands, and the Australian ones include a number from Mr. Fraser, Superintendent of the Botanic Gardens, Sydney, from the Blue Mountains, Moreton Bay, Port Macquarie and Melville Island, and other places.

Plants are also described from Tasmania (the vessel touched at Bass' Straits), King George's Sound, Kangaroo Island and Port Jackson, some of the plants having been collected by M. Gaudichaud.

The volume also contains some notes on New Zealand and Australian Algæ. Accompanying these is a folio atlas of 78 plates published in 1833, consisting of "Flore de la Nouvelle-Zélande," 39 plates, and "Sertum Astrolabianum" 39 plates.

Lesson, Rene Primevere (1794 – 1849). Born at Rochefort, 20th March, 1794, and died in the same city 28th April, 1849. He entered the Naval Service and became Pharmacien-en-chef of the Marine. He was a zoologist

mainly, though he pursued the study of botany. He became Professor of botany at Rochefort, and his botanical works include "Flore Rochefortine" (1836), and "Etude sur les farines." He published a "Journal d'un voyage pittoresque . . . la Coquille."

Co-operated actively with M. D'Urville in the botanical work of these expeditions and is commemorated by the following plants:—

Panætia Lessoni, Cass. = *Podolepis Lessoni*, Benth.; *Senecio Lessoni*, F.v.M. = *Erechthites arguta*, DC.; *Enchysia Lessoni*, Presl. = ?; *Stylidium Lessoni*. DC = ?; *Cyperus Lessonianus*, Kunth. = *C. trinervis*, R. Br; *Adenocystis Lessoni*, Hook., fil. et Harv. (fig. in "Phycologia Australica").

Richard, Archille (1794–1852). Born in Paris, 27th April, 1794, and died 5th October, 1852. He was the son of a distinguished botanist, Louis Claud Marie Richard. He was the author of a botanical text-book which passed through many editions in France and was translated into German, Dutch, Russian, and English (the last by William Macgillivray, Edinburgh, 1831). He was the author of other botanical books, and he probably was mainly responsible for the botanical results of the "Astrolabe" expedition already referred to. The following monographs are of interest to Australians:—

Monographie du genre *Hydrocotyle* (*Ann. Gén. Sc. Phys.* iv), Bruxelles, 1820, 8vo; Mémoire sur la famille des Rubiacées . . . (*Mém. Soc. Hist. Nat. Par.*, v) Paris, 1829, 4to.

He is commemorated by the following plants:—

Grewia Richardiana, Hook. = *G. latifolia*, F.v.M.; *Erechthites Richardiana*, DC. = *E. hispidula*, DC.; *Senecio Richardianus*, DC. = *S. australis*, Willd.

Achille completed the following work of his father, which does not, however, refer to the collections of any special expedition:—

"Mémoires sur les Conifères et les Cycadées," also entitled "Commentatio botanica de Conifereis et Cycadeis" . . . . opus posthumum ab Achille Richard, folio . . . Stuttgart, Cotta, 1826 large 4to. xv, 212 pp., 30 tab.

It consists of a "Premier Mémoire," devoted to Conifers, pp. 1 – 170, and a "Seconde Mémoire" devoted to Cycads, pp. 171 – 212. Specially interesting to Australians are the notes on and plates of *Dacrydium cupressinum* (N.Z.), *Phyllocladus rhomboidalis* (Tasmania), *Callitris rhomboidea* R. Br., *C. oblonga*, Rich.

The Cycad Memoir contains nothing specially dealing with Australian plants, except the "note sur l'opinion de M. Robert Brown, relativement à la structure des fleurs femelles dans les conifères et les Cycadées," at p. 203. No Australian Cycads are figured.

6. 1836-9. "Venus," commanded by Abel du Petit-Thouars.

The chief botanical interest concerning this expedition lies in the volume of plates published in 1846. The small volume describing the botanical results did not make its appearance until eighteen years later. The Australian plants are chiefly of the Western State.

Following is a title-page :—

"Voyage autour du monde sur la Frégate *La Venus*, pendant les années 1836 – 1839, publié par ordre du Roi, sous les auspices du Ministre de la Marine, par M. Abel du Petit-Thouars, Capitaine de Vaisseau etc." Atlas de Botanique, Paris, Gide et Cie 1846. Folio, 28 plates.

The text of the above was published in 1864, Paris, Théodore Morgand (se trouve aussi chez Gide). Botanique par *M. J. Decaisne* 8vo, pp. 34 and "Table des Matières 2 pp."

The plants figured are from Borneo; King George's Sound (W.A.); Isle Sulu; Natal; W. Coast of W. Australia;

South Coast of Australia; New Zealand; California; Tahiti and Marquesas; Philippines, New Ireland; Friendly Islands; Levuka (Fiji); Chatham Island (N.Z.); Malay Peninsula. The expedition visited Sydney.

Decaisne, Joseph (1807 – 1882). Born at Brussels 7th March, 1807. He went to Paris, and in 1824 was attached to the Jardin des Plantes, becoming, in 1832, assistant naturalist for rural botany under A. de Jussieu and began the publication of interesting works, which, in 1847, opened to him the gates of the Academy of Sciences. In 1848 he was appointed to the chair of Statistical Agriculture in the Collège de France, and succeeded M. de Mirbel, in 1850, as professor of "Culture" in the Museum. He was afterwards President of the Academy of Sciences and Director of the Jardin des Plantes. He died at Paris 8th February, 1882.

A distinguished botanist, who rose from the position of a simple gardener to be leading botanist in France, it is doubtful whether his reputation will so much be based on his botanical monographs as on his admirable pomological works. He worked at the plants of the "Venus" and "Astrolabe and La Zélée" expeditions.

For accounts of him see *Flore de Serres*, Tome 19, p. 29 (1873) with portrait, and *Gardeners' Chronicle*, 18th February, 1882, p. 215.

The following Australian plants commemorate him:—

Eucalyptus Decaisneana, Blume; *Tabernæmontana Decaisnei*, A. DC. = ?; *Andrachne Decaisnei*, Benth.; *Casuarina Decaisneana*, F v.M.; *Asparagopsis Decaisnei*, Kunth. = *Asparagus racemosus*, Willd.

7. 1837-40. "Astrolabe" and "Zelee," commanded by J. Dumont d' Urville.

The commander was unfortunately killed near Paris in the year 1842, as has already been stated, so that he was

not able to see the results of his last expedition presented to the world. Considering the predilection of M. D'Urville for botany, there is no doubt that botanists at large suffered a great loss by his tragic death.

An account of the scientific results (particularly as regards New Zealand) will be found at p. 393 of "The Sub-antarctic islands of New Zealand," (edited by Dr. Charles Chilton, and published by the Philos. Inst. of Canterbury, N.Z., 1909).

The botanical results published have little direct interest for Australian botanists. As M. D'Urville and M. Lesson had co-operated on former occasions in regard to botanical work, so in regard to the presentation of the results of this expedition a naval commander (**M. Jacquinot**), co-operated with a surgeon of the expedition (**M. Hombron**).

For an account of the exploratory work of D'Urville, see Dr. H. R. Mill's Introduction (p. xv) to Shackleton's "The Heart of the Antarctic."

Following is a title-page:—

Vol. I. "Voyage au Pole Sud et dans l'Océanie sur les corvettes *L'Astrolabe et La Zélée*, . . . pendant les années 1837, 1838, 1839, 1840 sous le commandement de *M. J. Dumont D'Urville*, Capitaine de Vaisseau, publié par ordonnance de sa Majesté, sous la direction supérieure de M Jacquinot, Capitaine de Vaisseau, Commandant de la Zélée." Botanique par **MM. Hombron et Jacquinot.** Tome Premier, Plantes cellulaires, par **M. C. Montagne, D.M.** 8vo. pp. 349. Paris, Gide et Cie, 1845.

The cellular plants described were obtained from Australia and New Zealand and its coast, the Pacific Islands, etc. The expedition collected, besides in Antarctica, at the following places amongst others:—Sydney, Port Essington, Raffles Bay, Darnley Island, Torres Strait, etc., but Hooker says that very few of the plants have been published.

Vol. II, (Title the same as Vol. I to here). . . Publié par ordre du Gouvernement sous le direction supérieure de M. Jacquinot Capitaine de Vaisseau, commandant de la Zélée. Botanique par *MM. Hombron et Jacquinot.* Tome Second. Plantes vasculaires, par **J. Decaisne,** Membre de l'Institut. 8vo. pp 96. Paris Gide et J. Baudry, 1853.

In the preface to Decaisne's volume (pp. 7–10), it is stated that the phanerogams were collected by M. Hombron. The plants described were collected in the Straits of Magellan, Auckland Isles and New Zealand. None were collected in Australia.

The plants generally were figured in a separate folio atlas with v + viii + xxxi plates, making 44 in all), some of the plates depicting several species. Decaisne's volume has at pp. 88–90 a "tabula iconum," of "Cryptogames vasculaires" i–v, and "Monocotyledones" i–viii, and "Dicotyledones" i–xxxi.

In the National Herbarium, Sydney, are a few specimens collected by M. Le Guillou, the author of the following work, at Raffles Bay :—

Le Guillou, Elie "Voyage autour du monde de L'Astrolabe et de La Zélée sous les ordres du Contre-Amiral Dumont d'Urville . . . 1837-40 . . . enriché . . . . de notes . . . . par (D. F.) J. Arago, Paris, 1844, 2 vols. 8vo."

Mr. Hedley tells me that Dr. Le Guillou wrote a series of zoological articles in which he is styled "Chirurgien-major de la Zélée."

The following botanists performed important services to Australian botany during the period of the circumnavigating expeditions, although they were neither attached to such expeditions, nor did they specially work upon the material brought home by such expeditions.

L'heritier (de Brutelle), Charles Louis (1746 – 1800). Born at Paris, 1746; assassinated in Paris (27 Thermidor, an x) 16th August, 1800. He came to England in 1786-7, and studied the Kew collections, which appear to have been freely placed at his disposal. See *Kew Bull.* 1891, 296; *Journ. Bot.* 1905, p. 325; Willdenow's "Principles of Botany" p. 490. Cuvier, Notice historique, Paris, 1800. (4) His principal works are:—

(1) Stirpes novæ aut minus cognitæ, quae descriptionibus et inconibus illustravit. Parisiis, typ. P. D. Pierres 1784 85, vi fasciculi. folio vi, 184 pp. 84 tab.

In bibliotheca Candolleana asservantur praeterea tabulæ 28 ineditæ fasciculorum vii et viii.

Tabulas ineditas 85 – 124 vidi in Bibliotheca Morettiane 91 tab., sign. 1 – 84, 7, 30, 52, 53, 56, 57, 59 bis.

(2) Sertum Anglicum, seu plantae rariores, quae in hortis juxta Londinum inprimis in horto regio Kewensi excoluntur, ab anno 1786-87 observatae. Paris, typ. Didot. 1788, folio, 36 p., praef., 34 tab. (Pritzel, *Thesaurus Literaturæ Botanicæ*)

The latter work is specially memorable to Australians, in that it contains the first description of the genus *Eucalyptus*, from specimens collected in Cook's Third Expedition at Adventure Bay, Tasmania. He is commemorated by the genus *Heritiera*, Ait.

Guillemin, Jean Baptiste Antoine (1796 – 1842). Born at Pouilly-sur-Saone, 20th January, 1796; died January, 1842, at Montpellier. Studied Pharmacy at Dijon and then botany at Geneva under J. P. Vaucher and P. De Candolle. In 1819 he went to Paris and was employed in the Delessert Herbarium and became conservator of it in 1827. A little afterwards he became aide-naturaliste in the Museum at Paris, and from 1830 to 1834 taught botany in the Institut horticole de Fromont. From 1838 to 1840 he was on a

botanical mission in Rio Janeiro. He was author of many botanical papers and other works. Of special interest to us are :—

(*a*) Icones Lithographicæ; plantarum Australasiæ rariorum. Decades duæ quas botanicis offert, J. B. A. Guillemin, Societ. Histor. Natur. Paris, Musæi Lessertiani Curator, Paris, 1827.

(*b*) "Enumération des plantes découvertes par les voyageurs dans les Iles de la Société, principalement dans celle de Taiti, par J. (B) A. Guillemin, aide de Botanique au Muséum d'histoire naturelle de Paris, Paris, 1837." In the text this work is headed "Zèphyritis Taitensis." 8vo. pp. 84.

The plants are those chiefly collected by MM. Moerenhout and Bertero, but those of Lay and Collie and other collectors and unpublished MSS. of Forster are employed.

"**M. Moerenhout,** négociant belge très distingué, aujourd'hui consul-general des Etats-Unis aux iles de la Société, avait expédié, en 1834, à M. d'Orbigny, une caisse de plantes récoltées par lui et par le docteur Bertero dans l'île de Taiti." (Guillemin's "Zephyritis Taitensis," p. 1.)

Moquin Tandon, Horace Benedict Alfred (1804–1863). Born at Montpellier, 7th May, 1804. Took his degree as M.D. In 1829 was professor of zoology at the "athénée" at Marseilles, and in 1833 was professor of botany at Toulouse. He was a distinguished litterateur. Went on a botanical mission to Corsica in 1850. Succeeded Achille Richard in the chair of "histoire naturelle medicale" at Paris, with charge of the plants of that faculty at Jardin des Plantes. Published medical works and also "Essai sur les dédoublements ou multiplications d'organes dans les végétaux. 4to. illustrated. Montpellier, 1826. His "Chenopodearum monographica enumeratio" (Paris, 1840) is valuable to all Australian students of saltbushes. He specialised also on the Amarantaceæ. He was author of "Elements de Téra-

tologie végétale" (Paris, 1841); "Polygalées Brasiliens" (with Aug. St. Hilaire) and other works on the same family of plants. Cooperated with the same author in a work on Capparidaceæ. Died at Paris, 15th April, 1863.

Mr. Hedley informs me that there is a brief obituary notice in the *Journal de Conchyiologie*, XII, 1864, p. 86-7. He was a distinguished ornithologist and conchologist as well as a botanist, also a member of the Institute. Went to Paris in 1853. For biography and list of works see *Toulouse Mém. Acad. Sci.*, v, 1864, pp. 5-46; *Adansonia*, v, 1864-5, pp. 149-175.

He is commemorated by *Atriplex Moquiniana*, Webb, also a monotypic genus of Cape Campanulaceæ, *Moquinia*.

Planchon, J. E. (1823-1888). Speaking of the "vast" Hookerian herbarium at Kew, "the chief foundation" of the *Flora Australiensis*, Bentham, who was never prodigal of personal praise, says,

"The value of this herbarium for a work like the present, is also greatly increased by the notes and determinations it contains from the hands of various botanists who have worked in it, and especially of Dr. Planchon, who had examined and corrected the determination of a large portion of the specimens it contained during several years that he had charge of it." (Preface to *Flora Australiensis* 8*).

Planchon had been Sir William J. Hooker's herbarium curator, and surely any account of the services of the early French botanists to Australia would be incomplete without a brief notice of him.

He was born at Ganges, Hérault, 21st March, 1823. He studied botany under Auguste Saint-Hilaire, and became Doctor of Sciences, 1844; Curator, Kew Herbarium 1844-49. Professor "Institut Horticole," Ghent, 1849-51. Doctor of Medicine and Professor in the School of Medicine and

Pharmacy at Nancy, 1851-3. Later on, he was Director of the School. "Correspondent" of the Academy of Sciences 1872. In 1873 was charged with a mission to America to study phylloxera-resistant vines and the way he performed his mission is a matter of history. Author of "Eucalyptus globulus" (*Revue des Deux Mondes*, January, 1875). Director, Botanic Gardens, Montpellier. Died at Montpellier, 1st April, 1888. An account of a memorial to him, with an illustration, will be found in the *Gardeners' Chronicle* for 13th April, 1895.

He is commemorated by *Drosera Planchoni*, Hook. f. = *D. Menziesii*, R.Br. var. *albiflora*; *Gnaphalium Planchoni*, Hook. f. = *Raoulia Planchoni*, Hook. f.; *Eucalyptus Planchoniana*, F.v.M.

Verreaux, J. P. This Frenchman, resident in Tasmania, was an active botanical collector, but I cannot trace any of his writings. If I can get further particulars of him I will gladly make them known. He was styled "Naturaliste," and was elected a member of the Tasmanian Society, 2nd January, 1843, see p. 74, *Tas. Journ.*, Vol. II; see also p. 159, where he is called J. P. Verreaux. In a list of members, at p. 160, his address is given as Hobart.

"Nov. Holl. specimine mihi humanissime oblato cum multis aliis plantis Novæ Hollandiæ, a Celeb. Inventore Verreaux dum hoc anno 1850 in nostra urbe degebat. Plurimas etiam alias stirpes ab hoc Naturæ Investigore repertas et ad Goodenovieas relatas, vidi in Herb. Musei Horti Parisiensis." ("Goodenovieæ" by H. De Vriese, p. 118 in dedicating *Dampiera Verreauxii* to him.)

This species = *Verreauxia paniculata*, Benth. *Croton Verreauxii*, Baill. also perpetuates his memory.

Coming rather later than the dates I have set as the limits of my paper, the name of **Anthelme Thozet** (1826–1878) should not be forgotten. He was a resident of Rock-

hampton, Queensland, for many years, where he introduced many useful plants and collected the indigenous flora most carefully. I have given notes of his life in my paper.[1] A valuable paper by M. Thozet on Aboriginal foods will be found in "Bulletin de la Société d'Acclimatation,"Jan.1873, under the title of "Quelques détails sur l'Australie," and also in *Revue Horticole* 1872, p. 182.

Works quoted—" Kew Catalogue of Portraits of Botanists " (*Kew Bulletin*, 1906, p. 72). Quoted as (1).

Biog. Universelle (Michaud) Ancienne et Moderne. Quoted as (2).

"Rév. Gén. Biogr." Ed. 2, Paris, 1844. Quoted as (3).

Nouvelle biographie générale, published by MM. Firmin Didot Frères under the direction of M. le Dr. Hoefer. Quoted as (4).

Catalogus Illustratus Iconothecæ Botanicæ Horti Bergiani Stockholmiensis, anno 1903 (Wittrock).

I am indebted to M. H. Lecomte of the Muséum d'Histoire Naturelle, Paris, and M. Cintract, 5 Rue Daubenton, Paris, for the portraits of MM. Bory de St. Vincent, de Jussieu, Brongniart and Moquin-Tandon, to Colonel Prain, M.D., F.R.S., Director of the Royal Gardens at Kew, for those of Labillardière, Desfontaines (in middle life) and Planchon, and to Mr. F. M. Bladen, Principal Librarian, Public Library, Sydney, for that of M. D'Urville. To Mr. Hugh Wright, Librarian of the Mitchell Library, I am indebted for several interesting notes, and to Mr. Charles Hedley, Assistant Curator of the Australian Museum, Sydney, for useful information.

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[1] "Records of Queensland Botanists," *Proc. Aust. Assoc. Adv. Science*, Brisbane Meeting, 1909.

Explanation of Plates.

Plate III.—J. J. De la Billardiere. From the lithograph by Julius Boilly. See p. 128.

Plate IV.—Bory de St. Vincent. From the "Dictionnaire des Sciences Naturelles, atlas biographique." Engraved by Ambroise Tardieu.

Plate V.—Rene Desfontaines. Original bears the inscription: "Déssiné d'après Nature à Paris en 1824, et Gravé par Ambroise Tardieu."

Plate VI.—Rene Desfontaines (in very old age). From original in Muséum d' Histoire Naturelle, Paris.

Plate VII.—Aime Bonpland. From a lithograph by Rud. Hoffmann, 1859, drawn by J. Haller from a photograph in the possession of Alexander von Humboldt. Published by George André Lenoir, Vienna. Lithograph in Botanic Gardens, Sydney.

Plate VIII.—Adrien de Jussieu. From a daguerrotype not later than 1850.

Plate IX.—Dumont D'Urville. Lithograph by A. Maurin, 1833. From the large plate in the collected works of the "Astrolabe."

Plate X.—Ad. Brongniart. From a painting by Marquerie, 1856, in the Muséum d' Histoire Naturelle, Paris.

Plate XI.—J. Decaisne. From "Flore des Serres," xix, 30 (1873).

Plate XII.—C. H. B. A. Moquin-Tandon. From a bust in the Muséum d' Histoire Naturelle, Paris, bearing neither signature nor date.

Plate XIII.—J. E. Planchon. From an illustration in a botanical or horticultural serial, which has not been traced.

WORM-NESTS IN AUSTRALIAN CATTLE DUE TO *FILARIA (ONCHOCERCA) GIBSONI.*

WITH NOTES ON SIMILAR STRUCTURES IN CAMELS.

By J. BURTON CLELAND, M.D., Ch.M. (Syd.), Principal Assistant Microbiologist, and T. HARVEY JOHNSTON, M.A., B Sc. (Syd.) Assistant Microbiologist.

(From the Government Bureau of Microbiology, Sydney, New South Wales).

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

FOR the last thirty years at least, fibrous nodules, containing in their centres much coiled nematode worms, have been known to be of frequent occurrence in the brisket and subcutaneous tissues of cattle from various parts of Australia. Though their presence has been often noted by various observers, a full description of the worm itself has never been published, owing to extreme difficulty in extracting it from its fibrous bed. However, in 1892 and 1893 two papers appeared dealing with part of its anatomy and with its pathological effects. Recently, we have had opportunities of examining a large number of the fresh nodules, and at last were fortunate enough to obtain those parts of the worm which are essential for descriptive purposes, with the result that the parasite appears to be one new to science. The object of the present paper is to deal with the worm-tumours themselves in all their aspects as pathological products. In another communication the parasite and its life-history will, as far as possible, be described.

Historical.—The first reference to these verminous tumours of which we are aware, is one by Dr. William

Morris,[1] read before this Society in 1880. He read notes on an encysted filaria found in the flesh of a bullock, and exhibited the cyst, portions of the mature worm and the embryo. He mentioned the dense white fibrous tissue capsule, and noticed that the nodules may contain more than one worm. In 1892 appeared an accurate article upon the subject by the late Dr. John Gibson[2] of Windsor, N.S.W. The specimens, the subject of his paper, were received from Mr. Stanley, the New South Wales Government Veterinarian, at the beginning of that year and were labelled "Tumours from the brisket of a fat bullock, containing filaria-ova viviparous." Dr. Gibson's descriptions of the pathology of the tumours and of the embryo worms and of those parts of the adults which he could extract are excellent. He was unable, however, to obtain adult heads and tails. He mentions that Dr. Cobb, of the New South Wales Department of Agriculture, had undertaken to work out the identity of the parasite, a matter which, if undertaken, was apparently never published.

In the same year, Dr. T. L. Bancroft[3] reported finding the nodules in oxen in Brisbane and Rockhampton (Q.) and mentioned their having previously been found by Dr. Morris and the late Dr. J. Bancroft.

In the following year (1893), Dr. C. E. Barnard and Mr. A. Park, M.R.C.V.S.,[4] submitted a paper entitled "Notes on Spiroptera associated with Tuberculosis in Cattle." They noted the resemblance of the tumours to those caused by

[1] Morris, *Proc. Roy. Soc. N.S.W.*, XIV, 1880, p. 337.

[2] J. Gibson, *Transactions of the Intercolonial Medical Congress of Australasia*, 1892, p. 576.

[3] Bancroft, T. L. "Notes on some Diseases of Stock in Queensland," in Report of the Chief Inspector of Stock and Brands for the year 1893, Queensland. Appendix, p. 4. Quoted by Tryon, *Queensland Agric. Jour.* Feb. 1910, p. 81.

[4] Barnard and Park, *Report Australasian Assoc. for Advancement of Science* v, 1893, p. 642.

Spiroptera reticulata of the horse, and appear to have identified their parasite, as far as it could be identified from the parts of the worms they were able to extract, as that species. They found caseation frequently, if not always, present in the tumours and made the remarkable statement that "tubercle bacilli are always associated with this disease."[1]

Though the worms have been well-known for so many years and have been continuously under the scrutiny of health and slaughtering authorities, who appear to have accepted Park's diagnosis of them, no further scientific reference to them appears until one of us in 1907 recorded their presence in cattle in West Australia.[2] This absence of any references may no doubt be interpreted as indicating that the disease plays little part in depreciating the value of the animal or of its meat.

In 1908-9, Mr. C. J. Pound in Brisbane, reported having received such nodules for examination, and in the latter year one of us[3] mentioned their occurrence in New South Wales cattle. Recently, however, the daily press has recorded that the presence of these nodules in Queensland meat in cold storage has been the subject of some concern to the authorities in London. As the parasite appears to be unknown outside of Australia, the nodules have in consequence been viewed with some unwarranted suspicion by the health authorities there.

The last published papers on the subject as far as we are aware, are one by ourselves describing shortly the parasite

[1] Tryon in *Queensland Agric. Journ.*, Feb. 1910, p. 81, has epitomized reports (dated August and September, 1893), letters and published writings by Park. In addition to articles in public newspapers, the latter include the following reference that we have been unable to consult—*Vet. Journ. and Annals of Comp. Path.* London (222) V. 37, Dec. 1893, pp. 102-7.

[2] J. B. Cleland, *Journ. Agric. West Australia.* xv, 1907, p. 88; reprinted in *Journ. Trop. Vet. Sci.*, iv, 1909, p. 491 – 8.

[3] T. H. Johnston, *Proc, Linn. Soc. N.S.W.*, xxxiv, 1909, p. 412.

as a new species, *Filaria gibsoni*,[1] the one by Mr. Henry Tryon already mentioned dealing with some of the literature and official papers, and another by Sydney Dodd[2] in the same number of the Queensland Agricultural Journal.

When examining a number of dromedaries imported from Karrachi in India into Western Australia in 1907, one of us[3] found in several animals, very similar fibrous worm-nests, though in general smaller in size. These were situated in the subcutaneous tissues of the neck (where one was mistaken during life for an enlarged lymph gland) and under the tail. The identity of this parasite has not so far been possible owing to failure to extract certain parts from the fibrous mass, so it cannot be said whether it is identical or not with that of cattle though we believe it to be so.

Geographical Distribution.—In Queensland cattle, slaughtered at the Sydney abattoirs, the nodules are common. Park's specimens were from cattle in the Burnett district of Queensland. Gibson quotes Stanley to the effect that at least 50% of the animals slaughtered in Sydney in or about 1892 were affected. This would include Queensland cattle, but also many bred in New South Wales. We are informed by Messrs. O. J. Vyner and W. G. Johnston of the Veterinary Division of the Health Department of this State that nodules can be found in cattle bred in the neighbourhood of Sydney. We have seen them from the northern rivers and western districts of New South Wales and from the Northern Territory of South Australia. Barnard and Park state that the disease is unknown in

[1] Cleland, J. B., and Johnston, T. H., "Worm-nests in cattle due to *Filaria gibsoni*, Preliminary Report," *Agric. Gazette, N.S. Wales*, XXI, 1910, p. 173-4.

[2] Dodd, Sydney, "*Spiroptera reticulata* in Cattle," *Queensland Agric. Journ.*, Feb. 1910, p. 86.

[3] J. B. Cleland, "Trypanosomiasis etc. in Camels" *Dept. Agric. West Australia*, Bulletin 34, 1909, p. 8 etc.; reprinted in *Journ. Trop. Vet. Sci.*, IV, 1909, pp. 316–344 (p. 324).

Tasmanian bred animals. As mentioned above, one of us has recorded the presence of the nodules in cattle in Western Australia.

Considering that the mammals of Australia are all marsupials, with the exception of *Canis dingo*, a few rodents, bats, and sea animals such as whales, seals, etc. and there are no indigenous bovines, it seems reasonable to suppose that these parasitic worms were introduced along with bovines or allied ungulates at one time or another. The alternative view is that the worm's natural host is one of the indigenous animals mentioned above, and that its occurrence in cattle is more or less accidental. This would presuppose that the filaria in question could develop to a great extent, if not entirely, in a new host removed by a large phylogenetic interval from its normal host, a condition unlikely to occur in such specialised parasites.[1] Further, in no indigenous Australian animal has any parasite been so far encountered resembling the one in question. The first hypothesis, therefore seems by far the most rational to adopt, and may be stated as follows:—*Filaria gibsoni* is an introduction from outside of Australia, having accompanied its true host with the importation of the latter. This true host is either some variety of domestic cattle or the buffalo now so prevalent in parts of Northern Australia or possibly a more distantly related ruminant such as the camel or some other ungulate such as the horse. It further follows that these parasites almost certainly do still exist in their original hosts in the country from which these came and will be found there on systematic search.

It may be of value to review here the sources from which Australian cattle, buffaloes and camels have been derived,

[1] A notable exception in Australia, to this rule is seen in the case of *Distomum hepaticum*, Abildg. This common parasite of cattle and sheep has been found on several occasions in the bile duct of herbivorous marsupials such as kangaroos and wallabies (*Macropus spp.*).

so as to ascertain where to search for the home of the parasite.

Apart from the importation into Australia on numerous occasions of cattle, sheep, horses, etc. from Great Britain, an examination of works dealing with the early history of these Colonies indicates several other sources. For instance in October, 1787, when Governor Phillip and the First Fleet touched at the Cape of Good Hope on their way to Australia,[1] they took on board two bulls, six cows, forty-four sheep and four goats, together with horses and hogs. For the greater part of a century after this date, doubtless many other vessels calling at the Cape similarly brought away some live stock. Cunningham[2] states that the horned cattle in New South Wales amounted to 21,513 in 1813 and to 68,149 in 1821, and were "derived from the Bengal buffalo variety, with smooth skins, short snail horns, and humpy shoulders, and from the various English breeds that have been at different times imported."

The Public Library authorities of Sydney have a MS. agreement between Captain Bremer and the Timor Government (1825) for the former to export cattle to Fort Dundas, a military and convict settlement founded on Melville Island off the coast of the Northern Territory of South Australia. Acting on this authority, buffaloes were imported in or before the year 1826, but whether other bovines accompanied them or not does not appear. When Major Campbell,[3] on September 19, 1826, relieved Captain Barlow at this post, he found that sixteen buffaloes for slaughter had just been landed from Timor. Later, in 1827 – 1829, the settlement was removed to Raffles Bay on the

[1] "History of New South Wales from the Records," Vol. I, by G. B. Barton, p. 72.

[2] "Two years in New South Wales," by P. Cunningham, Surgeon R.N. 1827, 2nd edition, Vol. I, p. 269.

[3] Campbell, "Memoirs of Melville Island and Port Essington." Communicated to *Royal Geographical Society*, London, 1834.

mainland, and the animals were transported thither. In 1846, the buffaloes in Northern Australia had increased to a great extent, and Leichhardt[1] saw herds of buffalo and the whole country "as closely covered with buffalo tracks as a well-stocked run in New South Wales could be with bullock tracks." If the spoor of an animal with a divided hoof seen by Sir George Grey[2] in the north-west of Australia in 1837-8, be really that of a buffalo, as he suggested, this may indicate that by means of Malay prows or in some other way, these animals had been introduced into another part of Australia some years before the settlement at Fort Dundas, though they may have wandered from the latter place, which is about a thousand miles away, in that time.

Camels seem to have been first introduced into Australia[3] by Sir Thomas Elder in 1866, when 124 were shipped from Kurrachee in India, 121 of which were landed at Port Augusta in South Australia. From this date, various other shipments have been made from time to time from India,[4] the last being the arrival in the north-west of Australia of 500 camels in 1907 from the same port as the first shipment. As it was in these latter animals that we found worm-nests, it may be supposed that amongst those arriving in 1866 some also contained these parasites. Camels are now common throughout the drier parts of Australia.

To summarize, it will be seen that cattle have been introduced to Australia from Great Britain and South Africa: that buffaloes were brought from Timor at least; and that camels came from India. Horses seem to have been derived from European breeds and Arab stallions.

[1] Extract from Leichhardt's Diary, 1846, in *South Australian Register*, 26 December, 1862.

[2] "Journals of Two Expeditions of Discovery in North West and West Australia," 1837-9 by George Grey Esq., Vol. I, 1841, p. 242.

[3] "Journey across the Western Interior of Australia," Colonel Peter Egerton Warburton, 1875. Introduction by Charles H. Eden, p. 118.

[4] Haji, S. G., "The Australian Camel Trade and Trypanosomiasis," *Journ. Trop. Vet. Science*, v, 1910, p. 72-88.

Worm-nests in cattle appear to be unknown in Great Britain, and, with such complete examinations as have been made, can hardly have escaped notice if present in South Africa. It therefore follows that if the natural host of the parasite is one of the breeds of common domestic cattle; the worm-nests may be present to-day in Indian cattle, whilst if the buffalo is that host, then those of Timor and allied parts should contain them. As already stated, our own observations show that *Filaria* (*Onchocerca*) *gibsoni* or a closely allied worm exists to-day in Indian camels, a fact which, (judging from a reference, in a recent Indian report by A. S. Leese, I.C.V.D.,[1] to the finding of them, under the term "Spiroptera nodules," by one of us in Western Australia), has not so far been recorded there.

Popular Nomenclature.—Amongst slaughtermen and those engaged in the meat trade, the nodules are known under such names as "stone-bruises" (from the supposition that they are due to injuries from lying on stony ground or perhaps from the density of the outer capsule), "white-kernels" or "kernels" (as distinct from lymphatic glands), "worm-nests" and "worm-knots," whilst the public are apt to view them as "cancers."

Macroscopic Appearances.—In living cattle, when the nodules are large or directly under the skin, they may actually be visible as rounded projections in the neighbourhood of the brisket or other parts and especially so if on the limbs. In one of the camels, a worm-nest was distinctly visible in the neck as a swelling the size of a walnut.

On examining the carcases of slaughtered cattle hanging up in an abattoir, the larger worm-nests at once attract attention as tense, firm, rounded projections embedded in the subcutaneous tissues or in the superficial layers of

[1] Report of the Veterinary Officer Investigating Camel Diseases for the year ending 31st March, 1909.

muscle, having thin and stretched tissues over them. The brisket seems to be by far the commonest situation for these tumours, and those more deeply embedded or of small size which are not visible to the eye during such inspection, may be often felt by running the hand over the surface with moderate pressure, when they feel like marbles in the underlying tissues. An incision into the healthy structures stretched over them at once enables the nodule to be enucleated with more or less ease. When thus removed, they are of a pale yellowish tint like fibrous tissue and vary in size from that of a small marble to tumours two inches or more in diameter. They vary in shape from more or less spherical in small growths to flattened ovals in the largest and are often of irregular contour shewing bosses and projections. The flattening and the irregularities of surface are probably all due to the resistance of the surrounding tissues, with consequent extension of the growth along the lines of least resistance.

On section of each nodule and towards its centre will be found the worm or worms in an intricately coiled mass, embedded in a comparatively loose but resistant fibrous stroma, with a varying quantity of serous or sero-sanguinolent fluid. This fibrous tissue is tunnelled by canals occupied by the parasite. The central worm mass proper varies very little in size in comparison with that of the whole worm-tumour; in other words, that found in the largest mass is little, if at all, larger than that found in a growth the size of a marble. This area occupied by the worm itself is completely enclosed in a delicate fibrous capsule which can be shelled entirely out of the dense, fibrous tissue forming the external coverings, leaving in the latter a cavity with slightly irregular walls. The outer covering consists of layers of very dense whitish fibrous tissue much firmer than that between the coils of the worm

itself and varying greatly in thickness according to the size of the whole tumour. In small growths, the layer is thin but in those of one or more inches in diameter, it is exceptionally hard and thick, and may form bosses and irregularities quite apart from the shape of the worm in its inner capsule.

Microscopic Appearances.—Sections of the outer fibrous wall show that it consists of dense fibrous tissue containing a variable number of blood vessels and cells varying in numbers in different parts. In some places are scattered leucocytes with numerous eosinophile granules. These may be dispersed singly or form columns between the fibrous tissue or be collected into considerable masses in a little fibrous stroma. Such cells constitute by far the majority of those met with in sections of the wall, ordinary polymorphonuclear leucocytes with few or no granules not being noticed. In addition to these cells are varying numbers of connective tissue cells and also in the fibrous stroma itself branching cells with basophile granules—the mast cells of the tissues.

Degeneration, Injuries, etc.—Occasionally, in the outer layers of the fibrous capsule, a considerable amount of dark venous extravasated blood is found apparently the result of direct injuries received during the last days of the animal's life, to which the prominence of the tumours render them especially liable. This blood rarely extends beyond the outer layers of the capsule. In instances where the injury is older, the nests become yellowish and degenerated, probably from cutting off of the blood supply.

A remarkable instance of a foreign body embedded in a tumour was found in one case whilst cutting sections. Buried about half-way through the outer capsule, was found a small fragment of woody or at least vegetable tissue showing portion of a vascular bundle, and leading obliquely

to this from the outside was a track in the centre of which was a bullock's hair (its identification was unmistakable). Apparently a foreign body, probably a stake, had penetrated the hide and wall of the nest, had carried in with it a hair or hairs from the surface, and had left behind it on withdrawal these latter as well as a fragment of its point. In the cavity occupied by these foreign bodies were a few embryos and eggs, showing that the central worm-mass had been itself injured.

We have seen a few instances in which the worm has apparently died and become in part calcified, as evidenced by gritty matter, effervescing with acid, which was collected in small masses resembling the coils of the worm. In other cases where the worm had died, the parasite was soft and becoming yellowish, and the surrounding tissue was also degenerated.

We have not seen any appearances other than the above mentioned simple calcification, which at all resemble the lesions of tuberculosis or actinomycosis, and further we have not found tubercle bacilli in such degenerated worm-nests. Barnard and Park, however, state that in 70 cattle slaughtered and examined by them, "tumours and absceses, varying in size from a walnut to a cocoanut, were found in all parts of the body, throat and neck, brisket, intestines, etc.; and while some were hard, others were softened down into purulent matter, but in each case . . the contents were encysted in a firm fibrous cyst wall." They then say that "these singular growths and abscesses" resembled in many features "tubercular masses, or those swellings due to the presence of actinomyces" but that "it was surprising to find them entirely due to the presence of a parasitic worm, which resembled the *Spiroptera reticulata* of the horse." Under a low power of the microscope, they saw "calcareous worm-casts" amongst the débris of purulent

matter and "upon using various stains tubercle bacilli were found mingled with the débris of the broken down tissue." Further on, they say that "as tubercle bacilli are always associated with this disease, possibly secondary to the parasite, the danger to the system of these tumours is obvious."

Although it is apparent from their general remarks about the parasite, that Barnard and Park are dealing with the same worm as ourselves, the above quotations are much at variance with our experience. It would appear, from their description, that abscess formation, caseation and calcification were almost the rule in the tumours they found, and that these changes were due to the presence of the tubercle bacillus which was always associated with the disease. We have not so far seen this combination of tuberculosis with the worm-nests, and, if it does occur, believe that it must be through a remarkable concatenation of events, for there seems no special reason why the tubercle bacillus should select the worm-nests in the subcutaneous tissues in which to develop. Barnard and Park's references to abscesses the size of cocoanuts and to degenerated nodules in the throat, neck and intestines make us inclined to believe that they were dealing with the presence of two separate and independent diseases, that the really tubercular areas were those found in the above mentioned sites (in which true worm-nests are rare), that the brisket nodules were due to the parasitic worms, and that some of these latter nodules may have been simply calcified and degenerated though possibly, in one or two instances, actually invaded by the tubercle bacillus. In fact, we have come to the conclusion that in the examination of their specimens, these authors must have mixed the tumours and abscesses from various parts of the animal, associating truly tubercular abscesses with caseous worm-nests and,

finding tubercle bacilli in some of the former, erroneously attributed them also to all of the latter.

Park's account, as given by Tryon[1] in his epitome already mentioned, is by no means clear. The following quotation "a condition in the young parasites breaking up into fragments almost in some instances identical like (to) tubercle bacilli, the encapsuled embryo would appear with methylene blue exactly like a giant cell or a multinucleated cell when prepared fresh" (*sic*), confirms us in our view that his worm-nests were rarely, if ever, the seat of secondary tuberculosis, in spite of his statement that the results he obtained showed clearly that "tubercle follows Spiroptera, but Spiroptera never follows tubercle." We have not seen any appearance such as "a small number of nodules" becoming "as large as a skittle pin, assuming much the same shape or lobulated like a kidney," nor do we think that the worm-nests are associated with lymphatic glands. In his second report, he stated that the specific name *reticulata*, which he gave the parasite did not imply that it was the same species as found in the horse. The name was given from the reticulate appearance of the tissue (quotation from a lay newspaper).

In Tryon's reference to Gibson's paper is the remark that this author found tuberculosis associated with worm-nests. This is evidently an oversight as no reference to such an association occurs in the original account. Sydney Dodd's communication already referred to supports our contentions as to the harmlessness (from a Public Health aspect) of the condition, the rarity of caseation or calcification, and the absence of any connection with tuberculosis.

Sites of the worm-nests and age of infected animals.— By far the most common seat of the worm-tumours in cattle is in the subcutaneous tissues over the brisket and

[1] Tryon, *l.c.*, p. 81 etc.

between the layers of its muscles. A number may be present in this situation (W. G. Johnston has counted 21), scattered over the part or several close together. Dr. Gibson also mentions their occurrence on the rump, and very rare instances in which they have been so numerous and so widely distributed over the body that the carcase has had to be condemned. Nodules have been noted just above the hock-joint, on the stifle joint and on the outer muscle of the thigh (silverside). Barnard and Park refer to their "abscesses" being found in the throat and neck and in the intestines, but, as our criticism elsewhere suggests, we believe many of these to have been due to tuberculosis pure and simple. Sydney Dodd[1] mentions that the nodules may be found in the connective tissues of any part of the body, even in very deep seated situations. In the camel we found them in the subcutaneous tissues of the neck and under the tail.

The presence of nodules is more common in old cattle. Gibson states it is rare to find them in animals under four years of age and in the Hereford breed of cattle. Barnard and Park did not find any in beasts under two years of age, from which they believe that the parasite takes a year or more to develop. We have examined three small nodules from a young calf, aged six to seven months, which came from the northern rivers of New South Wales.

The Economic Aspect.—The fibrous nodules, as usually found, do not affect in any way the health of the beast. If Barnard and Park's statements of the frequency of abscesses of tubercular nature being superadded to the worm-nests in cattle from the Burnett district of Queensland be correct, however, then consequent conditions of ill-health would supervene. We are disinclined to agree with them, as already stated, and believe they were dealing with two

[1] Dodd, *Queensland Agric. Journ.*, Feb. 1910, p. 86.

quite separate conditions, independent of each other, in the same animal.

As regards meat inspection, everything points to the harmlessness of their presence. During the preparation of the carcase by the slaughterman, the nodules are removed by a little snick with a knife over the stretched tissues when the worm-nest can be shelled out more or less easily. By running his hand firmly over the brisket, the meat-inspector detects any further small nodules hidden from view and removes these. The flesh of many thousands of cattle which have been thus treated, has been eaten by the inhabitants of Australian cities. Even were the worm-nests not so removed (and occasionally some do escape notice), no harm would follow. They would first of all probably be noticed either by the butcher or by the housewife; even if they escaped these two, and the carver at table, and were eaten unnoticed, no ill-results could be in any way expected. The worm itself is very small and, in its capsule and surrounded by fibrous tissue, is only about as large as a kidney-bean. Dr. Gibson's experiment on a young pup, fed on worm-nests for 15 weeks, at first alone and later with bread added, shew, it is true, that the animal at first became rapidly thin and emaciated, but it soon regained its good condition and remained well when the bread was added to the diet consisting only of worm-nodules. This shews that, even if eaten raw, the worms are devoid apparently of toxic effects. Where the worm-nodules are very numerous, as Dr. Gibson points out, the unsightliness of the carcase after their removal may lead to its condemnation.

If tuberculosis becomes associated with the worm-nodule—a condition which we believe to be rare, if it really ever occurs, but which Barnard and Park consider of great frequency—then, of course, the unwholesomeness of the part

is obvious and condemnation of part of the carcase or of the whole, as the case may be, would follow. Such a tubercular change in the worm-nest could not, of course, escape the notice of any person preparing or examining the carcase.

We are greatly indebted to Mr. C. J. Vyner, M.R.C.V.S., Chief Veterinary Inspector to the Department of Public Health, Sydney, for his kindness in supplying us with ample material for our investigations, and with valuable information as to the condition, and also to the three members of his staff, viz., Messrs. Everett and Vidler for obtaining blood films for us, and especially Mr. W. G. Johnston for furnishing much important data and specimens. We would also like to express our thanks to those members of the staff of this Bureau, who have so cordially assisted us in this investigation.

On the ANATOMY and POSSIBLE MODE of TRANSMISSION of *FILARIA (ONCHOCERCA) GIBSONI*.

By T. HARVEY JOHNSTON, M.A., B.Sc., Assistant Microbiologist and J. BURTON CLELAND, M.D. M.Ch., Principal Assistant Microbiologist.

(From the Government Bureau of Microbiology, Sydney, New South Wales.)

[With Plate XIV.]

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

Filaria (Onchocerca) Gibsoni, Cleland and Johnston, is a nematode parasite which causes the "worm-nests" not uncommonly found in Australian cattle. In another paper[1]

[1] Cleland and Johnston, "On the occurrence of 'worm-nests' in Australian cattle, etc.," *Journ. Proc. Roy. Soc. N.S.W.*, XLIV. 1910, p, 156.

we have dealt rather fully with the historical and pathological sides of the subject, whilst in the present communication we propose to deal with the zoological characters of the worm and the possible means of its transmission.

For the purpose of examining the anatomy of the worm in detail, the dense outer fibrous capsule was removed and the complete mass enclosed in its innermost thin capsule was shelled out. This inner capsule was then opened by means of small incisions, and in some cases its contents were carefully teased out at once, whilst in other instances the aids of early putrefactive processes and of pancreatic digestion were used to loosen the connective tissue surrounding the coils of the worm and enable larger portions of the parasite to be extracted undamaged.

An examination of all the fragments removed in this way from individual worm-nests revealed the fact that in many instances apparently only one female worm was present in each, that more rarely both a male and a female were present together, and that sometimes portions of at least two female worms were found. It must be borne in mind, however, that occasionally we entirely failed to extract either end of an individual (owing to the extreme difficulty in removing from its fibrous bed every portion of the worm) from which it will be obvious that the instances in which evidence of the presence of a single worm was alone obtained may really be less numerous than at first sight they appeared to be.

A brief description[2] of the worm has already appeared but we deem it advisable to give a corrected and more detailed account of it here.

General Description.—The body is greatly elongated and closely coiled. As we have stated above, it is very difficult

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[3] Cleland and Johnston, "Worm-nests in Cattle due to *Filaria Gibsoni*. Preliminary Report." *Agricultural Gazette N.S. Wales*, XXI, 1910, pp. 173-4.

to extricate the filaria, and consequently its length is not accurately known. We have measured all the fragments obtained by teasing out a nodule from which only one head (a female) was obtained, and found that the total length was 970 mm. Probably the male would be much shorter, as is usual in the Filariidæ. The greater part of the body in both sexes is uniform in diameter; that of the female being from 0·35 to 0·43 mm., whilst that of the male is only about 0·15 mm.

The whole of the cuticle, especially in the female, is ornamented with a very regular series of ridges (fig. 2) which travel round the body in a spiral fashion. There are really two series of spirals as each ridge may be traced to the next but one. This structure appears to be the same as that figured by Railliet[1] as occurring in *Filaria* (*Spiroptera*) *reticulata*, Dies. Each ridge is made up of a series of projections and depressions. Throughout the greater portion of the worm these ridges are very distinct, but anteriorly in both the male and female, especially the former, they become gradually less prominent and eventually indistinguishable. For instance, though very small they may still be seen in the region of the vulva. The following measurements taken from a female worm shew the progressive divergence of the spirals. Just behind the vulva they are very low and numerous, there being about 140 rings in 0·5 mm. This number decreases rapidly until there are 15, then 14 and so on until the usual number is from 6 to 8 in the same distance. In the case of the male there are about 100 rings in 0·5 mm. The ridges here are very small and closely set. The transverse striations figured by Railliet have not been seen by us in *F. gibsoni*. The cuticle, however, is very finely longitudinally striated.

[1] Railliet, Traité d. Zool. Agric. et Médicale, Edit 2, 1895, p. 539, 540; and reproduced in Neumann's "Parasites," 2nd Edit. (English Translation) 1905, p. 552, fig. 328.

All cuticular ornamentation appears to be absent from the tail and head end of the male.

The head end of the female is wider and more rounded than that of the male. At a distance of 0·65 mm. from the anterior extremity of the former, *i.e.*, just in front of the vulva, the breadth is 0·16 mm., whilst the diameter measured at the same distance in the case of the male is only about half of this, being 0·085 mm. Park[1] stated that he obtained from the pus of a "tumour," by washing, a head which (he said) agreed in all particulars as regards size and shape with the rest of the parasitic worm, but until more than one was obtained he could not be certain that it did belong to that worm. This head was stated to have "teeth-like projections and briar-like barbs encircling in a spiral manner in numerous rows . ." We cannot find anything resembling Park's description. If his observation[2] be correct, then the head cannot belong to this worm. Unfortunately we have not succeeded as yet in finding the tail-end of a female though we have obtained many male tail-ends. These taper gradually and end in a fine rounded extremity (fig. 3), the posterior end being somewhat loosely spirally coiled.

The mouth is small, rounded and terminal, and appears to be surrounded in the female by three slight projecting lips. In the male, however, there was no trace of labial structures. The œsophagus is long, its lumen being very narrow. It extends backwards to the region of the vulva, where it forms a small pyriform structure rounded at the anterior end, and whose transverse diameter is only slightly

[1] Barnard and Park, *Report Aust. Assoc. Adv. Science*, v, 1893, p. 644.

[2] On reconsideration we believe that Park really saw a larval pentastome (*P. denticulata* = *Linguatula serrata*). This would further support the view expressed in our previous paper that the tissues from different parts of affected animals examined by these authors were hopelessly mixed, the part in which the pentastome was found being almost certainly a mesenteric gland, which was possibly also tubercular.

greater than that of the gullet. This appears to represent a cardia, an organ which is stated to be rare in species of Filaria. The intestine passes back as a fairly wide tube. Its course may be straight, sinuous or at times looped. The anus in the male is situated at about 0·72 mm. from posterior extremity. The excretory system was not recognised. The nerve ring is a well-defined structure surrounding the œsophagus at about 0·18 mm. from the anterior end. The dermis of the body wall is relatively thick when compared with the muscle cells.

Special Characters of the Male.—The male worm, as mentioned above, is much thinner than the female and has a more delicate cuticular ornamentation. There is no depression of the body surface corresponding to that in the region of the vulva in the female. There are two unequal spicules. The larger is arcuate with a twisted stem and a sharp pointed extremity. The proximal end is enlarged as is usually the case. The length is about 0·197 mm. The second spicule is 0·082 mm. long (indicated by dotted lines in fig. 3), its distal termination being swollen and rounded. The cloaca is situated on a median prominence about 0·065 mm. from the end of the parasite. On each side of it are four blunt prominent papillæ which are peri-anal in position. There is a pair just near the caudal extremity, and at about midway between these and the hindmost of the peri-anal there is situated another pair. There is thus a total of six pairs. At the caudal extremity is a slight rounded bilobed structure which perhaps represents still another pair of papillæ. The arrangement of the papillæ is very much like that figured by Parsons[1] for *Filaria volvulus*. The gonad is double.

Special Characters of the Female.—The vulva is situated in a shallow depression at about 0·8 mm. from the anterior

[1] A. C. Parsons, *Filaria volvulus*, etc., *Parasitology*, I, 1908, p. 366.

end. Vaginal glands are present. The vagina is short and leads back into the large common uterine tube. The proximal part of the uterus may be considerably distended (fig. 1) by the mass of contained embryos. The main tube is a wide organ (0·07 mm. diameter) passing back for about 2·2 mm. where it bifurcates, each half being crowded with embryos. In some of the fragments they contain eggs, usually with a vermiform embryo within each, whilst in other fragments parts of the paired ovaries may be seen.

In our preliminary communication we stated that the worms were ovoviviparous and viviparous, but as a result of having examined more material we think that *F. gibsoni* normally is viviparous. As mentioned above, the uterus is crowded in its lower parts with free embryos, whilst further back eggs containing worm-embryos are mingled with the free embryos. We have seen the young worms escaping through the vulva. In two instances, however, we saw embryo-containing eggs in the vaginal region.

If a fresh "worm-nest" be cut across and a smear[1] be made from the cut surface, eggs and embryos in various stages of development will be met with. Apparently the ova after fertilisation develop very rapidly, the embryos being stored up in great numbers until a favourable opportunity for their liberation arises.

The fully developed embryo may be seen closely coiled up in its thin rounded or elliptical shell of about 0·03 by 0·045 mm. dimensions (fig. 3). Later, the little worm becomes free in the uterine cavity, the shell perhaps becoming absorbed as we have not noticed any empty egg-cases.

Its length now varies from 0·22 to 0·27 mm., being usually about 0·25 mm., the breadth being 0·003 to 0·004 mm. The anterior end is blunt and almost straight, the tail

[1] We have found Giemsa's stain to give the most satisfactory results.

being rather short but very thin and pointed. The œsophagus could be traced back for a short distance. The anus appears to be situated at about 0·021 mm. from the posterior end. The nerve ring is located relatively far back, being 0·07 mm. from the anterior end. The cuticle is very finely ringed, a few being indicated in the figure. Barnard and Park[1] drew attention to these very delicate structures and devised an ingenious method of using them to obtain the total length of the adult. They found that there were at least four hundred transverse striæ on the embryo, and on the supposition that these markings must necessarily become separated to form the striae of the adult, they argued that the multiplying of the distance between any two embryonic striae by 400 should give a rough estimate of the average length of the worm, viz., 36 inches. This agrees fairly well with our estimation of the length especially when one takes into consideration the fact that the striae of the embryo are very small and closely placed, and therefore hard to measure accurately. Any slight error must therefore become considerably accentuated when multiplied by 400. Our examination indicates that there must be many more than 400 rings in an adult worm, and this fact, together with the crowding together of those near the head end, at once discounts this method of estimating the total length. Barnard and Park gave the length of the embryo as being about one hundredth of an inch. Gibson's[2] measurements are 0·004 mm. wide by 0·25 mm. long. The embryos are capable of active movement in water for hours after their extraction from the nodule.

Filaria Nodules in Camels.—We have examined some similar filarial nodules obtained by one of us from two dromedary camels imported into West Australia from India.

[1] Barnard and Park, *loc cit.*, pp. 644-5.

[2] Gibson, *Trans. Intercol. Med. Congress of Australasia*, 1892, p. 579.

Owing to the fact that they had all been preserved in formalin, we had greater difficulty in making a thorough examination of the worms. The anterior end and body fragments show the same characters and measurements as those from the ox. The vulva is similarly placed. The ornamentation is alike, and the embryos are similar in regard to the head and tail ends and the annulations. We did not find any male specimens and consequently cannot absolutely identify the filaria from the camel as being specifically the same as that from the ox, though we have little doubt as to their identity since they agree in all points of comparison in regard to the female worms and in the subcutaneous habitat of the nematodes.

Comparison with other Camel filariæ.—The finding of this parasite in camels raises the question of its identity with *Filaria evansi*, Lewis. Apart from the differences in location of the parasites in their hosts (Lewis[1]) mentions that the adults of *F. evansi* were found in tangled masses plugging the pulmonary arteries, and were also present in the mesentery, we cannot find, in the meagre descriptions of the adults of *F. evansi* which are available to us, any references to a cuticular ornamentation comparable to that of our parasite or *F. reticulata*, features so striking as to at once arrest attention. Portions of an adult male filaria, presumably *F. evansi*, were taken from a bronchial tube of one of the West Australian camels. On examination it was seen that though it possessed fairly prominent annulations, yet it lacked the distinctive structures above referred to, and moreover the relations of the various parts at the head end were unlike in the two parasites. It was at first thought that this worm might be *Strongylus filaria*, Rud., a nematode which has frequently been found in camels in India, but this was not the case. We have also compared

[1] T. R. Lewis, *Proc. Asiatic Soc. of Bengal*, March 1882, p. 63, quoted in *Journ. Trop. Vet. Science*, II, No. 1, 1907, p. 151.

the embryos from the camel nodules with those taken by one of us from the blood of various camels in the same part of West Australia. These embryos[1] of *F. evansi* are of about the same length (0·23 mm.), but are much broader (0·006 mm.). In addition the tail is relatively larger and has a rounded end, whereas in the embryos of *F. gibsoni* it is very finely pointed. Then again the relations of the nerve ring and anus are different. Fine annulations are present in both.

E. and E. Sergent[2] mention that in Algeria a filarial embryo occurs commonly in the blood of camels which show subcutaneous abscesses, the latter being possibly due to the death and disintegration of the parent worms. The size of the embryos is given as 0·25 mm. long by 0·008 – 0·01 mm. in width with an obtuse anterior extremity and a moderately tapering tail. Thus these do not agree with our parasite. F. E. Mason[3] met with similar embryos in an Egyptian camel also affected with abscesses, but failed to find any adult worms in these though he succeeded in finding filariae allied to *F. equina*, Abildg (syn. *F. papillosa*, Rud.), in the blood-vessels of the male genitalia.

Comparison with certain bovine and other filariæ.—T. A. Ford[4] called attenion to the presence of "aortic worms" producing tumours in Malayan buffaloes. These parasites (Filariidae) were much more fully described, though not named, by G. L. Tuck,[5] who also noted a somewhat similar condition produced by another worm (also belonging to the

[1] It may be worth noting here that specimens of embryos of *Filaria evansi* were taken in one instance from a camel of only a month old (West Australia). This is almost certainly an instance of placental transmission.

[2] Ed. and Et. Sergent, *C. R. Soc. Biol.*, LVIII, 1905, p. 672, quoted in abstract in *Journ. Trop. Vet. Science*, II, 1907, p. 150.

[3] F. E. Mason, *Journ. Compar. Pathol. of Therapeutics*, XIX, 1906, p. 118, quoted in abstract in *Journ. Trop. Vet. Sci.*, II. 1907, p. 149 – 150.

[4] T. A. Ford, *Veterinary Record*, June 14, 1903, quoted by Tuck ([5]).

[5] Gnoh Lean Tuck, "Studies from Institute of Medical Research, Malaya," reprinted in *Journ. Trop. Vet. Sci.*, II, 1907, pp. 69 – 100.

Filariidae) in bullocks (Indian and Siamese). Both of these nematodes are quite distinct from *F. gibsoni.*

It is quite distinct from *Filaria labiato-papillosa*, Alessandr., (syn. *F. cervina*, Dies.) which occurs in the peritoneal cavity and adjacent connective tissues of cattle and various deer (*Cervidae*).[1] This parasite does not possess the cuticular ridges of *F. gibsoni* and has a quite different arrangement of papillae, being closely allied to *F. equina* of the horse.

It is now time that we should compare *F. gibsoni* with *Spiroptera reticulata*, Dies, or better, *Filaria reticulata*, on account of the position of the vulva and of other filarial characters. This species was first described by Diesing in 1841 and made a type of a new genus *Onchocerca*, Dies. The generic characters (freely translated) as given by him[2] are as follows:—Body filiform; male loosely spiral; female twisted into a close spiral; head continuous with the body; mouth terminal, orbicular; caudal extremity of the male excavated below and provided with two vertical lobes the base of each of which possesses a great number of small hooks and a papilla on the upper margin of each lobe; filiform penis between the lobes; female attentuated and genital aperture situated anteriorly, etc. The type species *O. reticulata*, Dies., is designated thus:—Body of female superficially delicately reticulo-annulate; male, length 1·5 cm., diameter 0·125 mm.; female, length 1·5 cm., diameter 0·25 mm. The host given is the horse. *Filaria reticulata*, Creplin, 1846, is given as a synonym. Dujardin,[3] Schneider,[4] and von Linstow,[5] do not mention the species. Davaine,[6]

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[1] Railliet, *loc.cit.*, p. 526-7.
[2] Diesing, 1841, quoted in his "Systema Helminthum," II, 1851, p, 287.
[3] Dujardin, Hist. Nat. des Helm. ou Vers intestinaux, 1845.
[4] Schneider, Monographie der Nematoden, 1866.
[5] Von Linstow, Compendium der Helminthologie, 1878; and Supplement, 1889.
[6] Davaine, Traité des Entozoaires etc., Paris, 1877, p. 103.

Railliet,[1] Neumann[2] and Law[3] give an almost literal translation of Diesing's description, but add *Spiroptera cincinnata*, Ercolani, (*S. cincinnati* in Law) to his list of synonyms. The various authors state that the parasite is peculiar to equines.

From the above it appeared that all the helminthologists who had touched on the parasite and whose works were available to us, had accepted Diesing's statements regarding the structure of the male worm. Accordingly we had no option but to separate our worm from *F. reticulata*. Since the publication of our preliminary note, in which we, like Barnard and Park, drew attention to the marked similarity of the adult worms (especially the females), we have had access to Pader's[4] paper on "Filariose du Ligament suspenseur du boulet chez le cheval," published in a journal which was not previously available in Australia. He dealt with the anatomy and histology of *F. reticulata*, and gave an account of the earlier references to the finding of this nematode. In his description he shows that the males of *F. reticulata*, like other Filaridæ, possess two unequal spicules instead of one as described by Diesing, but these are considerably longer than those of *F. gibsoni*. Besides this the arrangement and size of the papillae as given by Pader are quite different from those of the male of our worm.

C. W. Stiles,[5] in discussing the zoological characters of the genus *Filaria* Müller, points out that the type species *F. martis*, Gmelin, has a cuticle which possesses neither bosses nor striations. Hence, if the large genus *Filaria*

[1] Railliet, *l.c.*, p. 538-9.

[2] Neumann, Parasites (2nd English edition), 1905, p. 552-4.

[3] Law, Veterinary Medicine, v, 1903, pp. 439 - 440.

[4] J. Pader, "Arch. d. Parasitologie," IV, 1901, p. 58 – 95.

[5] Stiles, C. W., Bull. 34, Hyg. Lab. Public Health, Mar. Hospital Service, Washington, U.S.A., 1907, p. 32 – 36.

be split up (as has been done) into various subgenera, now generally regarded as genera, the members of the subgenus (or genus, *sensu stricto*) *Filaria*, should possess a similar cuticle to *F. martis*. *F. reticulata*, *F. volvulus* and *F. gibsoni*, could not accordingly be included. Diesing's generic name *(Onchocerca)* with *F. reticulata* as type is still available, but his generic diagnosis in view of Pader's work, would need to be corrected in that the males possess two unequal spicules. *F. gibsoni* and *F. volvulus*, Leuckt., would come under the genus amended as suggested.

It may not be out of place to recall the resemblance between the subcutaneous tumours produced in human beings by *O. volvulus*, to those caused by *O. reticulata* in horses,[1] and especially to those produced by *O. gibsoni* in cattle, and also to the worm tumours in camels. Besides this, the three parasites are very closely allied. The cuticular ornamentation is similar in all of them. Some excellent figures of *O. volvulus* are given by Fülleborn[2] and reproduced in an article on human filariæ by Fülleborn and Rodenwaldt.[3] The arrangement of the perianal and postanal papillæ is seen to be different from *O. gibsoni*. Parsons[4] has recently shown that the number and position of the papillae are different to those given by Fülleborn and very closely resemble those found in *O. gibsoni*. The shape of the spicules in these parasites is very similar. Our specimens were prepared according to the method advocated by Looss, and by Leiper.[5] Type slides have been presented to the Australian Museum, Sydney, co-types being retained by the Bureau of Microbiology, Sydney.

[1] Pader, *l.c.*, p. 80.

[2] Fülleborn, F., Beiheft 7, zum Arch. f. Schiffs u. Tropenhygiene, XII, 1908, p. 15 etc.

[3] Fülleborn, F. and Rodenwaldt, E., "Filarien" in Real-Encyclopädie der gesamten Heilkunde, Aufl. 4, p. 81 etc.

[4] Parsons, *l.c.*, p. 364 – 366.

[5] Leiper, Wellcome Research Labs., Khartoum, 3rd Rept,, 1909, p. 187.

Suggested means of transmission of the disease.—By analogy with *Filaria bancrofti*, Cobbold (*F. nocturna*, Manson) of man, an intermediate host might be expected to be the agent of transmission from animal to animal. Such a host would most likely be a species of mosquito, perhaps a biting fly, or possibly a tick, all being animals which pierce the skin and suck blood. Since the tumours are, in most instances, well below the surface of the skin and their capsules are thick, it would further be necessary for the embryos, set free from the mother, to escape into and be present in the general circulation. As the embryos would be extruded from the vagina of the parent into the serous or sero-sanguinolent fluid present in the innermost sac, they would require to pass out from this by way of the lymphatics, or through the small vessels after piercing them. Gibson describes finding the embryos both in the capsule of the worm-nests and in the trabecular network, the majority being in lymphatic spaces, but occasionally some were found in the interior of blood-vessels. Though, as this author has pointed out, the fibrous capsule and trabeculae are well supplied with blood-vessels, we have not noticed any large and definite vascular trunks escaping from the nodules. This abundant blood-supply is therefore probably obtained by small vessels piercing the capsule at many different points, and by these and by the lymphatic connections, the embryos could enter the systemic circulation. Gibson failed to find the embryos in the general blood stream, but adds that his observations were very imperfect. Barnard and Park refer, in an addendum to their paper, to finding "young *Spiroptera* in some of the blood-vessels" but do not state whether in those of the general circulation or of the wall of the worm-nodule.

We ourselves, in sections of the growths, have seen the embryos free in the fibrous stroma surrounding the coils of

the parasite and also in the layers of the outer capsule nearest to the centre, but have not detected them towards the periphery. So far, we have not found any in the lumina of small blood-vessels, those present, which were usually straight or sometimes slightly coiled, lying in the fibrous stroma presumably in lymphatic channels. Smears made by shaving off layers of the outer capsule, have shewn occasional embryos before the central worm-mass was reached. We have examined, with negative results, the following series of thick blood films, stained after removal of the haemoglobin by distilled water. These films were all taken at night (6 p.m. to 2 a.m.) in case of nocturnal periodicity of the embryos.

1. From ear of bullock:—Worm-nest on breast about sixth rib. Supposed to come from Northern Territory of South Australia.
2. From ear of bullock:—Worm-nests on both breasts about fifth rib.
3. From foot of bullock:—Two large worm-nests one on each breast about fifth rib. Upper Hunter River, New South Wales.
4. From foot of bullock:—Worm-nest buried in flesh at point of brisket and fourth rib.
5. From ear of bullock:—Worm-nests on each brisket from second to eighth rib. Queensland bred.
6. From foot of bullock:—Worm-nest embedded in flesh of brisket about second rib. New South Wales.
7. From foot of bullock:—Worm-nests on brisket. Queensland.
8. From foot of bullock:—Large worm-nests on each brisket, about fourth rib. Upper Hunter River, New South Wales.

Royal Society of New South Wales.

The Society's House,

5 Elizabeth Street, N., Sydney.

MAR 1 1911

Sir,

Will you please acknowledge receipt of Parts II & III, Vol. 44 of 1910 shipped to you this date.

Yours faithfully,

J. H. MAIDEN
F. B. GUTHRIE } Hon. Secs.

To

9. From ear of bullock:—Worm-nests on brisket. Upper Hunter River, New South Wales.
10. From ear of bullock:—Worm-nests on both briskets, sixth and eighth ribs. Queensland.

Twelve similar films from infected cattle, taken from the aortic blood during the day time (6 a.m. to 3 p.m.), were also negative.

It may be that the embryos can only escape in numbers into the circulation before the fibrous capsule has become much thickened, and hence would be found in this situation in only an occasional animal. It is obvious that, if certain *Diptera* are the intermediate hosts, embryos must, at one time or another be fairly numerous in the peripheral blood of certain animals at least, if the frequency of the infection is to be accounted for. Our results, however, do not support this hypothesis.

On the other hand quite another analogy presents itself in connection with the guinea-worm (*F. medinensis*, Velsch) of man. This worm after working its way through the tissues, eventually reaches a dependent situation such as the leg, where, after piercing the skin, it finally extrudes its embryos which escape into a fluid medium. A species of *Cyclops* or other freshwater crustacean probably then serves as an intermediate host, and later the developing parasite enters the human system in drinking water. Several points suggest that a similar life-cycle may occur in this cattle Filaria. One is that the worm-nests are almost always found in the subcutaneous tissues (we have a specimen in which the dermis itself is considerably thinned by the presence of the developing nodule), and especially in those over the brisket, a part of the body which would come in fairly close contact with the ground or a fluid medium when the animal was lying down or wallowing in water or mud. Another is that the screw-like external

bands round the body of the worm, are eminently suited for aiding its progress through the tissues of the host, the animal actually boring its way along. Such an architecture, indicating, we believe, the necessity for translation of the animal in the host's body, would be an extravagant waste in the case of a Filaria which merely had to extrude embryos into the circulating blood and to whom practically all the fibrous tissues, internal and external should be equally advantageous for its development.

This second theory is beset with a grave difficulty, however, which consists in the dense fibrous capsule which surrounds the worm, especially in the older nodules, and which is evidently a reactive process on the part of the tissues of the host to the irritative presence of the parent worm or of its struggling embryos. It can hardly be imagined that the adult form can escape from such a prison to wander to the surface and extrude its embryos. We are not at all certain, however, that this imprisonment in a thick capsule is the normal fate of the Filaria. We think that it is quite possible that, on their way to the surface and especially when the sexes are in conjugation, a certain number, perhaps many, of the adult worms, as the result of the irritation to the tissues that their progress through them produces, are arrested and finally surrounded by a fibrous capsule, which becomes thicker as time advances but which still leaves the worm and its embryos alive in the centre.[1] Those females, on the other hand, which escaped this fate, would reach the surface, pierce the epidermis, and liberate their embryos without perhaps doing any noticeable damage to the hide or attracting the attention of the slaughterman. An intermediate stage of the

[1] Manson ("Tropical Diseases," 3rd Edit.. 1903, p. 624) refers to the premature death in man of *F. medinensis* with the formation of abscesses or calcified cords, conditions somewhat analagous to the worm-nests of *F. gibsoni*.

life history would then probably occur in some fresh-water animal and the re-introduction of the parasite take place through drinking water containing these. So far we have not succeeded in finding the embryos alive after having been in water for more than a few days.

Escape of the embryos from the nodules through the agency of ingestion by a carnivorous animal can practically be excluded. Dingoes (*Canis dingo*) are the only animals in Australia that could play this rôle, and they could only do so by eating the nodules from a bovine that had died by accident in the bush, a comparatively rare event. Further, Dr. Gibson fed a young pup on minced worm-nests and bread for 15 weeks. On killing the animal 24 hours after eating its last meal of this nature, he found no nematode embryos in the blood and no living embryos in the stomach or intestines, though numbers of partly digested ones were found in the stomach and duodenum.

Barnard and Park's suggestion of direct transmission of the parasite we consider highly improbable. If such be the case, one would expect that animals harbouring a worm-nest would later develop an enormous brood of young nodules. One of our colleagues, Mr. G. P. Darnell-Smith, has, however, inoculated a number of living embryos into the subcutaneous tissues of a calf six months old and into a rabbit. As the former was only inoculated a short time ago, no results can yet be expected. The rabbit was also inoculated, but no embryos could be seen in blood smears taken four months later.

Fülleborn[1] and Rodenwaldt[2] in dealing with *O. volvulus*, mention that the embryos (which are similar in appearance to those of *O. gibsoni*) have not yet been found in the blood, though Brumpt[3] found them in the peripheral parts of the

[1] Fülleborn, *l.c.*, p. 15. [2] Fülleborn and Rodenwaldt, *l.c.*, p. 83.
[3] Brumpt, quoted by Fülleborn, *l.c.*, p. 15, 17.

tumours and thinks that they reach the lymphatics and finally the general circulation, and that consequently the transmitting agent might be a biting insect (*Tabanus*, *Glossina*, *Simulium*). He believes that transmission of *O. reticulata* occurs in the same way. As stated above, we have not succeeded in finding embryos of *O. gibsoni* in the blood of cattle.

Parsons[1] mentioned that in the case of *F. volvulus*, the parasite lives in a local dilatation of a lymphatic, and that the embryos probably pass from these into the general circulation, but that no observer had yet detected the microfilariae in the blood. By analogy, he considered the transmitting agent to be some blood-sucking insect.

ADDENDUM:—While this paper was in the press, one of us received from Professor A. Railliet of Alfort, France, amongst a number of reprints, a paper dealing with "Les Onchocerques etc." by Railliet and Henry (*C.R. Soc. Biol. Paris*, LXVIII, 1910, p. 248–251). In this note the authors cover some of the ground that we do in the above paper. They re-establish Diesing's genus *Onchocerca* with *O. reticulata*, Dies. from the foot of the horse as type, making a new species *O. cervicalis* for the parasite infesting the cervical ligaments of the same animal. *Filaria volvulus*, Leuckt. is also brought into this genus. A fragment of a female nematode taken from a worm-nest from the subcutaneous tissues of the head of a dromedary in the Punjab, by A. S. Leese, is described as belonging to a new species *O. fasciata*. The only information given concerning it is that the breadth is from 403 to 475μ, and that the cuticle possesses feebly undulating ridges repeated at every three or four striae. We have compared the *Onchocerca* (females) taken from the West Australian dromedaries, with that from local cattle, and notice that in the former the ridges

[1] Parsons, *l.c.*, p. 366-7.

are closer, lower and less pronounced than in the latter. Besides this transverse striae are present. The diameter of the female body in most of the segments examined was about the same in each case namely from 180 to 400 μ, more usually approximating the latter figure. We are able then to record the finding of at least two species of *Onchocerca* in Australia, viz., *O. gibsoni* in cattle and *O. fasciata* in camels.

During the past few days we have received the "Annual Report of the Veterinary Officer investigating Camel Diseases, for the year ending 31 March, 1910," by A. S. Leese, who on page 13 mentions the finding of *O. fasciata* fairly commonly, coiled up in nodules in the subcutaneous tissues. He goes on to say that the parasite does not cause any perceptible harm to its host. We might add that the first reference to the presence of this nematode (at that time unidentified) appears to have been made in 1909 by one of us, who found them in 1907 in dromedaries recently imported into West Australia from India (Cleland, Bull. 34, Dept. Agric., West Austr., 1909, p. 8).

Explanation of Plate.

Onchocerca gibsoni, Cleland and Johnston.

Fig. 1. Anterior end of female.
Fig. 2. Portion of body of female, shewing pattern on cuticle. A few longitudinal striæ are also represented.
Fig. 3. Posterior end of male
Fig. 4. Embryo in shell (drawn from a smear preparation).

All the above sketches were made with the aid of a camera lucida. Nos. 1 and 2 are equally magnified.

References to lettering:—*b.w.*, body wall (dermis and muscle); *a*, anus; *a.e.*, anus of embryo; *cu.*, cuticle; *cu r.*, cuticular ridges; *emb. sh.*, embryonal shell; *int.*, intestine; *l.str.*, longitudinal striæ; *m.*, mouth; *m.m.*, muscles attached to spicule; *n.r.*, nerve ring; *n.r.e.*, nerve ring of embryo; *o e.*, oesophagus of embryo; *oes.*, oesophagus; p_1, caudal papilla? $p_2 p_3$, post-anal papillae; p_4 four peri-anal papillae; *r.e.*, rings on cuticle of embryo; $sp._1$, $sp._2$, (dotted) spicules of male; *ut.*, uterus (main trunk); $ut._1$, $ut._2$, uterine branches; *v.*, vulva; *vg.*, vagina.

PALÆONTOLOGY OF THE LOWER SHOALHAVEN RIVER.

By CHAS. F. LASERON.

[Communicated by R. T. BAKER, F.L.S.]

[With Plates XV, XVI, XVII, XVIII, XIX.]

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

Introduction.—The following palæontological notes have been made entirely from material obtained during the course of an investigation into the nature and relations of the sedimentary rocks of the Lower Shoalhaven River.[1] Of the fossil contents of these formations, it is of course obvious that the efforts of one collector over such a wide area have by no means exhausted the material: but in spite of this, the great variety and abundance of fossils obtained in some localities prove one at least of the formations to have had a rich and varied fauna. Therefore, while much yet remains to be done before, the list of fossils from the district is in any way complete, it is nevertheless hoped that the present paper will serve as a basis for future work on the subject.

The collection of fossils here dealt with, is to be presented to the Technological Museum, with the exception of the described specimens of *Mytilus* (types A and B) and *Astartila* (types A, B, C, and D), which will be presented to the Mining Museum.

I must here mention my indebtedness to Mr. W. S. Dun, Palæontologist to the Mines Department, who has, in the preparation of this paper, generously given me the benefit of his large knowledge and experience.

[1] C. F. Laseron, this Journal, XLII, 1908, p. 316.

PALÆONTOLOGY.

(1.) **Permo-Carboniferous**, *Upper Marine Series*.—In considering the relations of different sedimentary formations to each other, and the various changes in the geography of any one district during one geological period, too much attention cannot be paid to fossils. In the Shoalhaven and neighbouring districts, the geologist is perhaps very fortunate, for the conditions which prevailed during the deposition of that division of the great Permo-Carboniferous epoch, known as the Upper Marine Series, are very clearly portrayed, and the localities in which fossils occur numerous, and the fossils themselves well preserved. So that here at least it is possible to a fairly large extent, to correlate the fossils with the geographical changes which have taken place, and to form an estimate of the conditions under which they lived.

Most of the fossils obtained are marine in character, and come from the two formations known as the Wandrawandian Series and the Nowra Grits. These are the intermediate divisions of the Upper Marine Series, the whole of that formation being divided in the Southern Districts into the following subdivisions in ascending order :—

(1) Conjola Beds.
(2) Wandrawandian Series.
(3) Nowra Grits.
(4) Gerringong Series (Syn. Crinoidal Series, Nowra to Berry Shales).

In the first three of these formations, but little collecting has yet been done, while on the other hand the Gerringong Series have received considerable attention from the very earliest of Australian and other noted geologists, and their outcrops on Cambewarra Mountain, Gerringong, and Wollongong have all been prospected by many collectors, notably the Rev. W. B. Clarke. Consequently, though

much is yet to be learnt of the fossil contents of this formation, still the list is of a sufficiently complete nature to enable a comparison to be made.

The Wandrawandian Series is perhaps the richest in fossils in the Shoalhaven district, and from them comes most of the material which is here dealt with. Burrier was the most profitable locality, and from here within a short distance, 42 species have already been obtained. At Grassy Gully also a good variety occurs, and here 16 species were procured.

The vertical range of species in the Permo-Carboniferous formation is a most important subject, which has as yet been but little touched upon. Unfortunately but little comparison can be made with the Upper Marine Series in the Maitland District, for the various horizons there, though definite, nevertheless have been laid down under very different conditions to those in the south, the local geography having in each case been at that time essentially different.

Great care must be taken in the division of sedimentary formations into horizons by their fossil contents alone, for it is necessary, not only to observe the difference, but to ascertain how much of it is actually due to the natural extinction of old with the development of new species, and how much is merely caused by a redistribution of species due to changes in conditions, the one series migrating to new habitats, and the other arriving from neighbouring areas to take its place. This is exemplified in the Wandrawandian Series from Yalwal Creek to Burrier, where along one horizon, a complete change in fauna takes place due to local conditions. So that working on fossil evidence alone, the rocks at Yalwal Creek, Grassy Gully and Burrier would seem to belong to entirely different formations.

On the other hand, the similarity between the fossil contents of the Wandrawandian Series and the Gerringong Series is exemplified by the following table, where it will be seen that most of the genera, abundant in the one formation, are found in the other, though a considerable vertical range separates the two. In pointing out this similarity, it is meant not so much to denote a large percentage of common species, but has reference rather to the numerical proportions of the various genera. Thus in both the Wandrawandian and the Gerringong Series, pelecypods are remarkably abundant, such types as the Pecten group, *Pachydomus*, *Stutchburia*, *Astartila*, *Chaenomya*, *Maeonia* etc., being very abundant in the two formations, while the proportion of the common brachiopods such as *Martiniopsis*, *Spirifera* and *Dielasma* to these is about the same.

Table comparing the Fossil Contents of the Southern sub-divisions of the Upper Marine Series.[1]

Gerringong Series at Gerringong[2]	Nowra Grits.	Wandrawandian Series.[3]
PLANTÆ—		
Fucoid remains	Fossil wood	Fossil wood
Coniferous wood		
POLYZOA—		
Stenopora crinita, Lonsd		
—— *tasmaniensis*, Lonsd.		*Stenopora tasmaniensis*, Lon.
Fenestella fossula, Lonsd.		*Fenestella*, sp. indet.
—— *internata*, Lonsdale		
POLYPORA—		
Protoretepora ampla, Lon		
ECHINODERMATA—		
Tribrachycrinus corrugatus, Ratte		*Tribrachycrinus Clarkii*, McC
Phialocrinus Stephensi, Eth. fil		*Phialocrinus sp.*
ASTEROIDEA—		Genus indet.
ACTINOZOA—		*Zaphrentis sp.*
BRACHIOPODA—		
Lingula ovata, Dana		
Orbiculoidea, sp. ind.		
Dielasma hastata, J. de C. Sowerby and varieties		*Dielasma hastata*, J. de C. Sow.
		—— —— var. *globosa*, Las
—— *cymbaeformis*, Morris		—— *cymbaeformis*, Morris
—— *inversa*, de Kon.		
—— *amygdala*, Dana		

Table comparing the Fossil Contents of the Southern sub-divisions of the Upper Marine Series[1]—*continued.*

Gerringong Series at Gerringong.[2]	Nowra Grits.	Wandrawandian Series.[3]
BRACHIOPODA—		
Martiniopsis subradiata, Sowerby and varieties	*Martiniopsis subradiata,* Sow	*Martiniopsis subradiata,* Sow
—— *oviformis,* McCoy	—— *oviformis,* McCoy	—— *oviformis,* McCoy
Spirifera tasmaniensis, Mor		*Spirifera tasmaniensis,* Mor.
—— *verspertilio,* Sowerby	*Spirifera verspertilio,* Sow.	—— *verspertilio,* Sowerby
—— *Strzeleckii,* de Kon.		—— *Strzeleckii,* de Kon.
—— *Clarkei,* de Kon.	—— *avicula?* Sowerby	
—— *avicula,* Sowerby		
Spiriferina duodecimcostata, McCoy	*Productus brachythaerus,* Sw	*Productus brachythaerus,* Sw
	—— —— var. *elongatus,* Eth. fil. et Dun	
PELECYPODA—		
Deltopecten subquinquelineatus, McCoy		*Deltopecten subquinquelineatus,* McCoy
—— *leniusculus,* Dana		—— *Fittoni,* Morris
		Aviculopecten ponderosus, Eth. fil. et Dun
		—— *Englehardti,* Eth. fil. et Dun
		—— *media,* Laseron
Merismopteria macroptera, Morris		*Merismopteria macroptera,* Morris
		Mytilus sp. (type A)
		—— (type B)
		Aphanaia gigantea, de Kon.
Maeonia elongata, Dana		*Maeonia elongata,* Dana
—— *valida,* Dana		—— *carinata,* Morris sp.
—— *fragilis,* Dana		—— *recta ?* Dana
—— *carinata,* Dana		*Cleobis grandis,* Dana
		—— *robusta,* Laseron
Chænomya Mitchelli, de K.		*Chaenomya Mitchelli,* de K.
—— *Etheridgei,* de Kon.		—— *Etheridgei,* de Kon. and varieties
—— *undatus,* Dana		—— *undatus,* Dana
		Burriera Dunii, Laseron
Astartila polita, Dana		*Astartila polita,* Dana
—— *cyprina,* Dana		—— *(Pachydomus) sp.* (t.A)
—— *cytherea,* Dana		—— *sp.* (type B)
Pholadomya? glendonensis, Dana		—— *sp.* (type C)
		—— *sp.* (type D)
Clarkia myiformis, de K. *(Notomya securiformis,* McCoy)		*Pleurophorus gregarius,* Eth. fil. var. *inflata,* Las.
Stutchburia costata, Morris		*Stutchburia costata,* Morris
		—— *compressa,* Morris
		Solenomya translineata, Las.
Nuculana Darwinii, Dana		*Nuculana ovata,* Laseron
GASTEROPODA—		*Solenopsis sp.*
Platyschisma oculum, Sow.	*Platyschisma oculum,* Sow.	*Platyschisma oculum,* Sow.
—— *depressum,* Dana		

Table comparing the Fossil Contents of the Southern sub-division of the Upper Marine Series[1]—*continued.*

Gerringong Series at Gerringong.[2]	Nowra Grits.	Wandrawandian Series.[3]
GASTEROPODA—		
Mourlonia Strzeleckiana, Morris		*Mourlonia Strzeleckiana*, Morris
Ptycomphalina Morrisiana, McCoy		*Ptycomphalina Morrisiana*, McCoy
Murchisonia verneuliana, de Kon.		*Capulus sp.*
		Euomphalus ? sp.
PTEROPODA ?—		
Hyolithis lanceolata, Mor.		
Conularia lævigata, Morris		*Conularia inornata*, Dana
—— *inornata*, Dana		
Agathiceras micromphalus, Morris		*Agathiceras micromphalus*, Morris
—— *undulatus*, Dana		
Orthoceras		

[1] The fossils of the Conjola Beds, in which but little collecting has as yet been done, are not here listed.

[2] The list of fossils from Gerringong is taken from an appendix written by W. S. Dun, to "The Geology of Gerringong" (Harper), *Rec. Geological Survey of N.S.W.*, vol. VIII, part 2, p. 106.

[3] To these must be added the fossils collected by E. C. Andrews, and listed in "Report on the Yalwal Gold Field," Mineral Resources of N.S.W.. No. 9, p. 20. It is probable that the lower and middle portions of the Upper Marine Series at Yalwal, mentioned by Mr. Andrews, belong to the Wandrawandian Series, their thinness being due to the fact that the Devonian rocks in the neighbourhood attain a high altitude. The upper portion is probably part of the Nowra Grits, and the only fossils which are found here, and not found near Nowra, are *Pachydomus pusillus*, McCoy, and *Spirifera duodecimcostata*, McCoy.

Most of the fossils of the Wandrawandian Series seem to have come from the lower horizons, for the upper portion of the formation is almost devoid of animal remains. At Burrier, immediately above the fossiliferous horizon, a bed of gritty sandstones is overlain by another series of finely laminated shales and sandstones, which are very barren; and so far beyond a few badly preserved *Zaphrentis*, but few fossils have been obtained. Taking the Wandrawandian Series as a whole, they seem to have had a more littoral origin than the Gerringong Series, and thus show a greater variation over short distances.

Again the intermediate formation, the Nowra Grits, displays great differences from both of the other formations, and evidently a great change in conditions took place, which caused both an alteration in the nature of the sediments, and in their fossil contents. The Nowra Grits really represent a temporary break, which has interrupted what would otherwise be continuity of conditions from the Wandrawandian to the Gerringong period, with the resulting production of one comparatively uniform formation.

For instance, the Wandrawandian Series were laid down during a steady period of subsidence, the rate of which corresponding approximately with the rate of sedimentation kept conditions uniform. During the deposition, however, of the Nowra Grits, a sudden check of this subsidence, with possibly in some places a slight elevation, altered conditions materially. Portions of the sea-bottom were probably again elevated above sea level, and brought within the action of the breakers and of atmospheric agencies, so that the neighbouring sediments became coarser, and subsidence having ceased, the sea became rapidly shallow. That this was the case can be seen by the fact that false bedding is exceedingly common in the Nowra Grits. The fauna also had changed, the abundant and varied forms of the Wandrawandian Series having either died off, or migrated to more congenial surroundings, and only the more common forms of brachiopods, which evidently stood a wider range of conditions than the more highly differentiated pelecypods still remained. Fossil wood is sometimes met with in the Nowra Grits, one piece found at Longreach consisting of a thin carbonaceous film, lying on the bedding plane, and over a foot in length by about $2\frac{1}{2}$ inches across. This shows that the shore line at this time was evidently not far distant.

Again, however, subsidence took place, and on the resumption of old conditions, nearly all the same fauna

returned from neighbouring areas, with the result that a remarkable similarity exists between the fossils of two formations, which are nevertheless separated by one of a widely different nature.

To denote the exact situation where specimens have been found, bracketted letters are placed after the name of the locality, and these correspond with the lettered localities on the sketch map, published with the previous paper.[1]

GLOSSOPTERIS BROWNIANA, Bgt. (Prodrome, 1828, p. 54.)

Loc. Yalwal Creek (L).

Hor. Freshwater Beds (Conjola Beds).

Obs. Very common in some horizons. The specimens found consist of large suboval leaves, with obtuse apices, and narrow oblique venation, multi-anastomosing right to the margin. The venation is very similar to that of *G. Browniana* figured by Feistmantel,[2] and the midrib is but apparent from the centre to the apex of the fronds.

NOEGGERATHIOPSIS HISLOPI, Bunbury. (Quart. Journ. Geol. Soc., vol. XVII, p. 334, pl. x, f. 5).

Loc. Yalwal Creek (L).

Hor. Freshwater Beds (Conjola Beds).

Obs. The only specimen found is identical with that figured by Morris[3] under the name of *Zeugophyllites elongatus*, and also by Feistmantel.[4] This is now synonymised by Arber[5] under *N. Hislopi*, Bunbury.

[1] This Journal, Vol. XLII, plate xliv.

[2] Geol. and Pal. Relations of the Coal and Plant Bearing Beds in Eastern Australia and Tasmania, plate 17, fig. 13, pl. 13, fig. 4, and pl. 20, fig. 2.

[3] Strzelecki, Phys. Desc. of New South Wales and Van Dieman's Land p. 250, pl. 6, figs. 5, 5a.

[4] Feistmantel, *loc. cit.*, pl. 21, fig. 6.

[5] Arber, Catalogue of the Fossil Plants of the Glossopteris Flora in the Department of Geology, British Museum, page 179,

Stenopora tasmaniensis, Lonsdale. (Darwin's Geol. Obs. Volc. Islands, 1844, p. 161).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Several specimens were found of which one has the appearance of being attached to the shell of a *Spirifer*, having probably grown upon the shell after the death of the bivalve.

Fenestella sp., indet.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Rare; only a few fragments found.

Tribrachycrinus clarkii, McCoy. (Ann. Mag. Nat. Hist. xx, 1847, p. 228, pl. 12, fig. 2).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Only one plate was found, but this corresponds very well with that figured by de Koninck.[1]

Phialocrinus sp.

Loc. Shoalhaven River (A).

Hor. Wandrawandian Series.

Obs. The cast of one plate was found in this locality.

Asteroidea (Genus ?)

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. A portion of what is evidently a starfish was found, consisting of the casts of a number of plates; but the specimen is too poorly preserved to even hint at the genus.

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[1] Palæozoic Fossils of New South Wales, pl. 6, fig. 5e.

ZAPHRENTIS SP., indet.

Locs. Shoalhaven River (B); Burrier (D).

Hor. Wandrawandian Series.

Obs. One fair specimen from the first locality is over two inches in length, in the shape of a bent horn; but in the absence of a section it is impossible to name it specifically. The Burrier specimen is very poor.

DIELASMA HASTATA, J. de C. Sowerby. (Min. Con., 1824, v, p. 66 and 446).

Locs. (1) Grassy Gully (F); Burrier (D); (2) Shoalhaven River near Nowra (Q).

Hor. Wandrawandian Series; Nowra Grits.

Obs. The typical form is abundant both at Burrier and Grassy Gully, but not so common in the Nowra Grits.

DIELASMA HASTATA, J. de C. Sowerby, var. GLOBOSA, var. nov.

The following is the description of an internal cast, the only specimen found :—Contour of dorsal valve transversely oval. Contour of ventral valve with its greatest width for base, that of a depressed isosceles triangle. Ventral valve considerably the larger. Thickness through united valves equal to height of dorsal valve. Foramen fairly large and sloping. The surface is ornamented by a number of shallow converging folds, corresponding to growth markings.

Dimensions:—Height to beak of ventral valve $\frac{2}{3}$ of an inch; width of dorsal valve $\frac{3}{4}$ of an inch; height of dorsal valve $\frac{1}{2}$ an inch; thickness of united valves $\frac{1}{2}$ an inch.

Loc. Longreach, Shoalhaven River (A).

Hor. Wandrawandian Series.

Obs. This remarkable little shell is characterised by its great width and depth. The ventral valve is slightly compressed, but this has had no effect upon the contour of the

dorsal valve. The researches of Davidson[1] upon this genus have shown *D. hastata*, Sow. to be so variable, and his illustrations show such a complete transition between extreme types, that I hesitate to create a new species upon one specimen, which is only an internal cast. The Shoalhaven shell approaches nearest to fig. 11, plate 1, in the work quoted, but is much farther removed from the typical form than even this illustration. The differences are such that if further material be obtained it may be necessary to raise this *Dielasma* to specific rank.

DIELASMA CYMBAEFORMIS, Morris. (Strzelecki's New South Wales and Van Dieman's Land, p. 278, pl. 17, figs. 4 and 5).

Loc. Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. Only one rather poor specimen was found.

MARTINIOPSIS SUBRADIATA, Sowerby sp. (Darwin's Geol. Obs. Volc. Islands, p. 158).

Loc. Grassy Gully (F); Burrier (D).

Hor. Wandrawandian Series.

Obs. Common at Grassy Gully, both as testiferous examples, and as internal casts. Rarer at Burrier. At the latter locality an internal cast was found showing well the internal spiral processes.

MARTINIOPSIS OVIFORMIS, McCoy sp. (Ann. Mag. Nat. Hist. xx, 1847, p. 234, pl. 43, figs. 5, 6).

Loc. (1) Shoalhaven River near Nowra (Q); (2) Shoalhaven River (A).

Hor. (1) Nowra Grits ; (2) Wandrawandian Series.

Obs. Internal casts fairly abundant at Q. One good cast was found at A.

[1] British Fossil Brachiopods, Vol. II.

SPIRIFERA TASMANIENSIS, Morris. (Strzelecki's N.S.Wales and Van Dieman's Land, p. 280, pl. 15, f. 3 and 4).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. This species is fairly abundant at Burrier.

SPIRIFERA VERSPERTILIO, Sowerby. (Darwin's Geol. Obs. Vol. Islands, p. 158).

Loc. (1) Shoalhaven River near Nowra (Q); (2) Burrier (D).

Hor. (1) Nowra Grits; (2) Wandrawandian Series.

Obs. Good internal casts were obtained in fair abundance at Q, and several testiferous examples from Burrier.

SPIRIFERA STRZELECKII, De Kon. (Pal. Fossils of N. S. Wales, p. 183, pl. 13, f. 1, and pl. 14, f. 1).

Loc. Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. Fairly plentiful in this locality.

PRODUCTUS BRACHYTHAERUS, Sowerby. (Darwin's Geol. Obs. Volc. Islands, p. 158).

Loc. (1) Shoalhaven River near Nowra (Q); Shoalhaven River (C); (2) Burrier (D); Grassy Gully (F).

Hor. (1) Nowra Grits; (2) Wandrawandian Series.

Obs. Internal casts were very abundant at C. Only one specimen was found at Burrier.

PRODUCTUS BRACHYTHAERUS, Sow. var. ELONGATUS, Eth. fil. et Dun. (Rec. Geol. Survey N.S. Wales, VIII, pt. 4, 1909, p. 299, pl. 42, f. 2, 3 and 7).

Loc. Longreach, Shoalhaven River (C).

Hor. Nowra Grits.

Obs. One specimen was found, displaying well the large recurved ventral beak, and the narrow form, characteristic of this variety of what is a remarkably variable species.

AVICULOPECTEN PONDEROSUS, Eth. fil. et Dun. (Monograph on Carb. and Permo-Carb. Invert., Vol. II, pt. 1 The Palaeopectens, p. 10, pl. 5; pl. 12, f. 4).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. One specimen was found, of a large, highly convex valve, with imperfect auricles, which nevertheless are separated distinctly from the valves. The costae are of two orders, one secondary rib being placed between each pair of primary ribs. This character does not, however, appear to be constant enough to be relied upon, for in one portion of the shell the secondary costae are quite absent. In the original description, two secondary costae are mentioned as being interspersed between each of the primary.

AVICULOPECTEN ENGLEHARDTI, Eth. fil. et Dun. (Monograph on Carb. and Permo-Carb. Invert., Vol. II, pt. 1, The Palaeopectens, p. 17, pl. 9, f. 6–11; pl. 14, f. 6–8).

Loc. Burrier (D); Grassy Gully (F); Sugar Loaf (I and J); Yalwal Creek (N).

Hor. Wandrawandian Series.

Obs. Mostly small internal casts were found, but at Burrier several testiferous specimens were obtained. In most cases the auricles were absent and broken, but one specimen shows the interior of a valve with both auricles well preserved. This shell has a fairly wide distribution in the Shoalhaven district, but is always found in approximately the one horizon of the Wandrawandian Series; and is thus of considerable stratigraphical value. It is noteworthy also, that in the Shoalhaven district this species is uniformly smaller than the type.

Aviculopecten media, sp. nov. Of the type of *A. profundus*, de Kon.,[1] and *A. squamuliferus*, Morris.[2]

Specific Characters:—A medium sized, nearly circular shell, equilateral without the wings, and nearly equally convex, the right valve being slightly the larger, with the umbo elevated above the hinge. The right posterior auricle is large and almost rectangular, slightly rounded on the outer margin, and ornamented by 9 or 10 low rounded radii, crossed by faint wavy growth lines. Hinge line nearly equal to greatest width of shell. Left posterior auricle large and indented with a marked byssal sinus. Anterior auricles not perfect, but ornamented also with radiating striae. Posterior and anterior slopes equal and fairly steep, but not ridged. Auricles distinct. The test is thin, and ornamented with about 25 equal, rounded costae, which are also prominent on the internal cast. Intercostal spaces broad and smooth.

Dimensions:—The largest specimen found was $2\frac{1}{2}$ inches in depth; and the dimensions of a nearly perfect cast are: length, $1\frac{1}{4}$ inches, height $1\frac{3}{8}$ inches, thickness of united valves $\frac{5}{8}$ of an inch.

Relations and Differences.—This species undoubtedly approaches very closely to *A. profundus*, de Kon., but after careful examination, I have no doubt that it is distinct. The chief points of difference may be summed up as follows:

(1) The number of costae in *A. media* is only about 25, instead of 40 as in *A. profundus*.

(2) In *A. profundus* the radii are crossed by numerous growth lines, producing a cancellated surface. The surfaces of the radii in *A. media* are quite smooth.

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[1] Eth. fil. et Dun, Monograph on Carb. and Permo-Carb. Invert., Vol. II, pt. 1 The Palaeopectens, p. 9, pl. 11, f. 4 and 5.

[2] Strzelecki's Phys. Descr. N.S. Wales, 1845, p. 278, pl. 14, f. 1.

(3) The hinge line of *A. media* is slightly shorter than the greatest width of the shell, that of *A. profundus* is broader.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Two specimens were found; an imperfect right valve with a well preserved auricle, and a nearly perfect cast of the united valves.

DELTOPECTEN SUBQUINQUELINEATUS, McCoy. (Ann. Mag. Nat. Hist. 1847, xx, p. 398, pl. 17, f. 1).

Loc. Grassy Gully (F); Burrier (D).

Hor. Wandrawandian Series.

Obs. This is one of the most common species at Grassy Gully, and specimens are splendidly preserved. In the large series collected, the outline was somewhat variable, ranging from almost circular to longitudinally oval. There is, however, no break in the continuity of the variation, and the specimens are all evidently one species. Some of them are testiferous, and in a number of the casts, the large chondrophore is very well shown. One good specimen showing two orders of costae was found at Burrier.

DELTOPECTEN FITTONI, Morris sp. (Strzelecki's N.S.Wales and Van Dieman's Land, 1845, p. 277, pl. 14, f. 2).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Two good specimens of this species were found at Burrier, both with portion of the shell preserved and showing plainly the large chondrophore.

MERISMOPTERIA MACROPTERA, Morris sp. (Strzelecki's N.S. Wales and Van Dieman's Land, 1847, p. 276, pl. 13, f. 2, 3).

Loc. Burrier (D); Cambewarra Mountain.

Hor. Wandrawandian Series; Gerringong Series.

Obs. This is one of the most common species at Burrier, and like most of the other pelecypods, specimens are well preserved.

MYTILUS SP. (Type A.)

Description.—Shell small and wedge-shaped; contour of united valves regularly cordate. Nearly equivalve, the left valve being slightly the larger. Ventral and posterior margins rounded. Anterior margin straight. Umbos terminal, fairly prominent, and twisted anteriorly, overhanging the anterior margin. Hinge line short, curved and edentulous. Shell of moderate comparative thickness, and somewhat horny.

Dimensions.—Height $\frac{1}{4}$ of an inch; width $\frac{5}{32}$ of an inch or $\frac{5}{8}$ of the height; thickness of united valves $\frac{3}{16}$ of an inch or $\frac{3}{4}$ of the height.

Loc. Burrier (D); Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. The best specimens were found at Burrier where they are very abundant and well preserved; but internal casts are also fairly abundant at Grassy Gully. This and the following species (type B) will on further investigation probably prove to be new, for no very small mytiloid shells have as yet been described from the Permo-Carboniferous of New South Wales. Both species are however held, pending the work of Messrs. Etheridge and Dun on the genus, in which they will be finally dealt with.

MYTILUS SP. (Type B.)

This is a slightly larger shell than the preceding, with sharp pointed umbos, recurved anteriorly. The posterior margin is broadly expanded, and rounded, the anterior margin incurved and slightly concave, the umbos extending beyond. Hinge line fairly long and straight. Ornamenta-

tion plain, consisting of a few moderately deep growth wrinkles.

Dimensions.—Height $\frac{1}{4}$ of an inch; width $\frac{5}{16}$ of an inch or $1\frac{1}{4}$ times the height.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. This species therefore differs from the preceding in the relative proportions of its height and width, in length of hinge line, in its concave margin, and in the broad expansion of its posterior portion. Three specimens were obtained from Burrier, all of approximately the same dimensions.

APHANAIA GIGANTEA, de Kon. (Pal. Fossils of N.S. Wales, p. 240, pl. 21, f. 6).

Loc. Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. One large internal cast was found, besides several small casts which may belong to this species. The prismatic layer in this shell is very thick, which causes the test to be very brittle; and this is probably the reason for its rarity, for in several localities in the district fragments of shells were found which evidently belonged to this species.

MAEONIA ELONGATA. Dana. (Amer. Journ. Science, 1847, IV, p. 158).

Loc. Junction of Yalwal Creek and Shoalhaven River (N); Burrier (D).

Hor. Wandrawandian Series.

Obs. At the first locality rather indifferent internal casts were fairly common, but at Burrier numerous fine testiferous specimens were obtained.

MAEONIA CARINATA, Morris sp. (Strzelecki's N. S. Wales and Van Dieman's Land, p. 273, pl. 11, f. 3 and 4).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Very abundant both as casts and as testiferous examples. Internal casts of this species show pittings similar to those on specimens from Bundanoon. They appear as small elevations on the cast, not more than $\frac{1}{32}$ of an inch in diameter. They are very irregularly scattered, and are never present on the posterior side of the keel. In the space of one square inch 29 were counted. The irregularity of their occurrence evidently denotes that they are not structural, and in addition to this they are not present in all specimens. Possibly they are the product of some corroding disease. In the original figure several pittings are shown but no mention is made in the text.

MAEONIA (?) RECTA, Dana. (Amer. Jour. Sc. 1847, IV, p. 154)

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Only one specimen was found, an internal cast of both valves. Whether this specimen is really a *Maeonia* is open to considerable doubt. The flat unkeeled valve and the absence of a gape, evidently remove it from the genus, but the specimen is not well preserved and approaching very closely to Dana's *Maeonia ? recta*,[1] it is retained provisionally under that species.

CLEOBIS GRANDIS, Dana. (Amer. Journ. Sc. 1847, IV, p. 154).

Loc. Burrier (D); Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. Large shells evidently referable to Dana's species are fairly abundant at Burrier. Casts show the hinge line to be edentulous. The adductor muscular impressions are faint, the anterior being the more prominent; and the pallial line is simple.

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[1] Geol. Wilkes' U. S. Explor. Exped. p, 698, Atlas pl. 7, f 2.

Oleobis robusta, sp. nov.

Description.—The following is the description of a left valve—the best specimen found—Shell large and ovoid, inflated, the cast being flattened for about half an inch from the anterior and dorsal margins. Beak anteriorly situated, prominent, overhanging the hingeline and incurved. From the appearance of the cast, the shell substance was somewhat thick, particularly near the beak. Ventral margin broadly and regularly curved, anterior and posterior margins semi-circular, the anterior and prominent umbo preventing what would otherwise be a regularly oval shell. Anterior adductor impression oblong, about $\frac{3}{4}$ of an inch along its greatest dimension, which is parallel to the margin, well defined but shallow, and situated about $\frac{1}{3}$ of the distance between the ventral margin and the apex of the shell. Pallial line indistinct but apparently simple. Hinge line curved and edentulous. There is no trace of sculpture on the cast.

Dimensions.—Length 4 inches; height $2\frac{3}{4}$ inches; depth of cast of left valve $\frac{7}{8}$ of an inch.

Loc. Burrier (D); Junction of Yalwal Creek and Shoalhaven River (N).

Hor. Wandrawandian Series.

Obs. Only two specimens were found, both casts, the type coming from Burrier. On comparing them with other specimens of *Cleobis*, we find that the nearest resemblance is to the species of Dana originally described as *Maconia grandis*.[1] From this, however, *C. robusta* differs in its contour, which apart from the umbo forms a regular oval. *M. grandis* on the other hand is more oblique and inflated, with recurved not incurved umbos, and in addition evidently has a relatively thinner shell.

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[1] Geol., Wilkes, U.S. Explor. Exped, p. 597, pl. 6, f. 8.

CHÆNOMYA MITCHELLI, de Kon. (Pal. Fossils of N. S. Wales, p. 205, pl. 16, f. 3).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Several specimens were obtained.

CHÆNOMYA ETHERIDGEI, de Kon. (Pal. Fossils of N. S. Wales, p. 206, pl. 16, f. 2; pl. 17, f. 3).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Only one typical specimen was found.

CHÆNOMYA ETHERIDGEI, de Kon., var.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Four specimens were obtained, which approach nearer to *C. Etheridgei* than to any other species; but the upturned posterior portion of the shell is absent and the gape is more ventrally situated.

CHÆNOMYA UNDATUS, Dana. (Geol. Wilkes' Explor. Exped. 1849, p. 687, pl. 2, f. 11).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Very abundant, both testiferous and as internal casts.

BURRIERA, gen. nov.

Generic Characters.—Test triangular and flat. Equivalve and inequilateral, but not markedly so, with a marked anterior gape. Test fairly stout and gradually thickening towards the anterior termination, which is sharp and acuminate. Anterior margin abrupt and remarkably truncate, the shell at first sight appearing as if broken. Posterior margin rounded. Posterior adductor impression

prominent, and the anterior very faint. Pallial line simple. Hinge line very short and edentulous, the umbos sharp and pointed. Ornamentation simple, concentric, but almost smooth.

Obs. The specimens on which this genus is founded are two in number, one a testiferous left valve, and the other a nearly perfect cast of a right valve. Both these specimens are on the one slab, and were previously exhibited at a meeting of the Linnean Society.[1] The remarkable truncate anterior margin of this shell seems to separate it entirely from nearly all the known pelecypods, and its characters generally all seem to place it in a group by itself. The family Lunulicardiidæ of Fischer seems to be the only one with which it possesses any affinities.

Dall's[2] description of this family is as follows:—"Usually equivalve, triangular shells with terminal beaks, from which a sharp ridge runs toward the lower margin, bounding a flattened area. Hinge margin straight, long. Internal characters unknown." He mentions the following genera as belonging to the family:—*Lunulicardium*, Munst; *Patrocardium*, Fischer; *Mila*, *Tenka*, *Babinka (Matercula)*, *Amita (Spanila*, *Tetinka)* of Barrande.

Lately John M. Clarke[3] has described from the Devonian of North America, a number of remarkable examples of *Lunulicardium*, and some of these[4] show sharply truncate margins similar to *Burriera*, but the ornamentation and other characters are essentially different. However, the greatest interest is attached to Barrande's genera.[5] These, from the Silurian of Bohemia are all characterised by a marked keeling of the lateral region. In every case, how-

[1] Proc. Linn. Soc. of N. S. Wales, 1909, vol. xxxiv, p. 118.
[2] Zittel, Text-book of Palæontology, vol. i, p. 367.
[3] Naples Fauna in Western New York.
[4] Notably *L. clymeniae*, plate 2, fig. 5.
[5] Système Silurien de la Bohême (Acephales, 1882).

ever, this is apparently a distinct keeling, not a truncation, the shell being bent inwards almost at right angles, whereas in *Burriera* the shell itself is not infolded, but abruptly cut off, so that the surface of the interior forms an even angle with that of the truncation. The ornamentation in these Silurian genera also, is radial not concentric.

From a stratigraphical point of view, the discovery of one of the Lunulicardiidae in Australia is of no less interest. Previously the family had not been found in strata newer than the Devonian, therefore its range must now be extended from the Silurian to the Permo-Carboniferous. As to be expected in the wide interval bridging the Devonian from the Permo-Carboniferous, considerable evolution had taken place in the group, and *Burriera*, which was so far the last survivor, was really an extreme of evolution, and differed considerably from what were probably its ancestors.

BURRIERA DUNII, sp. nov.

Specific Characters.—Test triangular, anteriorly elongated, and acuminate. Posteriorly rounded. Both valves nearly flat, with a well marked anterior gape. Test gradually thickening towards the acute anterior termination, where it attains its maximum. The anterior margin is sharply truncate and straight, the truncate surface being at right angles to that of the valve. This at first sight suggests that the shell has been broken. The posterior adductor impression is prominent, and equal in diameter to nearly one third of the height of the shell. It is rounded on its lower and inner edges, and slightly ridged upon its ventral margin. The cast of this impression shows eight thin, parallel, curved ridges (striations upon the test) running obliquely over its surface towards its upper inward margin. The anterior adductor is very faint and is hardly distinguishable. The pallial line is simple and straight, and above it and running parallel to it, is another faint lineal

impression, which does not however extend entirely across the valve. The sculpture is concentric, and the surface of the test is ornamented with a number of equidistant shallow growth folds. This ornamentation is continuous upon the truncate anterior margin, bending at an acute angle upwards towards the umbos.

Dimensions.—Breadth 2 inches; height $1\frac{1}{2}$ inches; thickness of united valves probably under $\frac{1}{2}$ an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Only two specimens of this most remarkable shell were found, and these were on the one slab. One is a nearly perfect internal cast of a right valve, and the other is a testiferous left valve. It is named in honor of Mr. W. S. Dun, Palæontologist to the Mines Department.

ASTARTILA POLITA, Dana. (Amer. Jour. Sc., 1847, IV, p. 155)

Loc. Shoalhaven River (A).

Hor. Wandrawandian Series.

Obs. Several internal casts were found in this locality.

ASTARTILA (PACHYDOMUS) SP. (Type A.)

Specific Characters.—A medium sized shell, nearly circular in outline and inflated; anteriorly viewed, elongate cordate. Umbos prominent, anteriorly situated and recurved. Hinge line curved and posterior to the umbos, with a well marked, elongated external (opisthodetic) ligament. Adductor impressions unequal; the anterior the more prominent, rounded ventrally, and straight on the dorsal margin; the posterior shallow. Situated above the anterior muscular impressions are two smaller but sharply defined impressions, which served for the attachment of the pedal muscles. Pallial line simple and well marked. Hinge line of right valve provided with one large cardinal tooth, fitting into a corresponding socket on the left valve.

Test very thick and strong. Ornamentation concentric, consisting of regular, broad and shallow growth folds.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. This species comprises some of the best preserved of all the specimens obtained from Burrier, where it is very numerous. Two very fine testiferous specimens, consisting of the united valves were found, besides numerous single valves and casts. The general characters of this shell agree very well with the description by Morris of his genus *Pachydomus*, but Dana's *Astartila* has, according to his own description, a somewhat thinner shell. Other shells belonging to the same group are very abundant at Burrier, but their identification is at present attended with considerable difficulty. The fact that many of the original descriptions were taken from very imperfect material, the types of which have either been lost, or are in collections in foreign museums, throws many obstacles in the way of the student. The genus *Pachydomus* of Morris appears to be a good one, but as to how near *Astartila* of McCoy approaches this, is very uncertain.

As the Burrier specimens are especially well preserved, full descriptions are here published for future reference. It must be understood, however, that such a classification is entirely provisional, and the species are chiefly described to aid in future recognition, and to assist the future elucidation of this most difficult group. Moreover, I have less hesitation in leaving this work in abeyance as there is a probability of casts of the types of Dana's work[1] shortly arriving in Sydney, when the group will be revised by Messrs. Etheridge and Dun.

ASTARTILA (PACHYDOMUS) SP. (Type B).

Description.—A small oblique ovate shell, with high, prominent, anteriorly situated umbos; slightly elongated

[1] Geol. of Wilkes' U.S. Expl. Exped.

behind. Shell substance moderately thick. The cast shows a low ridge (depression on the interior of the shell) running obliquely from the umbos toward the posterior extremity. Unfortunately there is not sufficient shell substance preserved to ascertain whether this depression marked a fold on the exterior of the shell. The small piece of shell still adherent to the cast is moderately thick, and shows the sculpture to have been concentric and regular but not pronounced. The anterior adductor impressions are faint, the posterior the most prominent, broad and shallow and situated high in the valve. Pallial line indistinct. Hinge line short and straight, the cast showing the right valve to have had one prominent cardinal tooth, fitting into a corresponding socket in the left valve.

Dimensions—Length 1 inch; height $\frac{3}{4}$ of an inch; thickness of united valves of cast $\frac{1}{2}$ an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Only one specimen was found—an internal cast of both valves with some shell still adherent. The large cardinal tooth and thick shell, evidently show this to be co-generic with *Astartila* (*Pachydomus*) *sp.* (type A).

ASTARTILA SP. (Type C).

Description—Shell almost circular in form, somewhat inflated, and very slightly elongated behind. Owing to variation in the thickness of the shell, the cast is almost triangular. Umbos not very prominent, and almost centrally situated. Ligament external (opisthodetic), but short and narrow. Adductor impressions very faint and almost indistinguishable. Pallial line not visible. Shell somewhat thin, particularly in the centre. Ornamentation concentric, consisting of numerous fine growth wrinkles. On the cast and running obliquely towards the posterior

extremity are two low, diverging plications or ridges, which would be grooves on the interior of the test. These are quite invisible on the exterior of the shell. Hinge line short and curved, showing in one specimen the trace of what might be a cardinal tooth, similar to the other species of *Astartila* already dealt with.

Dimensions—Length $1\frac{1}{3}$ inches; height $1\frac{1}{3}$ inches; thickness of united valves $\frac{11}{16}$ of an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. This is one of the common species at Burrier, and specimens are well preserved, though somewhat difficult to extract.

ASTARTILA SP. (Type D).

Description—Shell broadly oval, with the general external appearance of a typical modern *Tapes*. Beaks moderately prominent and anteriorly situated. Hinge line fairly long and curved, with long narrow opisthodetic ligament. Margins regularly rounded. Shell substance moderately thin. Ornamentation as in other members of the genus, concentric, consisting of numerous growth wrinkles. Internal structures unknown.

Dimensions—Length 1 inch; height $\frac{3}{4}$ of an inch; thickness of united valves $\frac{1}{2}$ an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Several good specimens were found at Burrier, but it is not so common as the other species.

PLEUROPHORUS GREGARIUS, Eth. fil. var INFLATA, var. nov.
(Rec. Aust. Mus., vol. III, 1897–1900, p. 185, pl. 2–5.)

Description—Valves equal, soleniforme, elongated, almost quadrangular, somewhat rounded behind. The shell is much inflated, the section of the united valves being

almost circular in outline. Beaks slightly flattened above, situated at the anterior extremity, overhanging and incurved. Dorsal and ventral margins approximately parallel, the dorsal with a slight infold, corresponding with an arching of the ventral margin, and giving the whole contour a very slight curve. Anterior adductor fairly prominent, sub-circular, its cast being sharply ridged upon its ventral margin. Posterior adductor larger, but not so prominent. Pallial line simple. Hinge line probably edentulous. Shell moderately thick, and ornamented with close deep concentric growth wrinkles. No radial striae at all were discernible.

Dimensions—Length $2\frac{1}{4}$ inches; height $\frac{7}{8}$ of an inch; depth of one valve $\frac{3}{8}$ of an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Several specimens were found, both as casts and with portion of the shell still adherent. Considerable doubt is at present felt as to whether this shell is only a local variety of *Pleurophorus gregarius*, or a new species of *Stutchburia*. To the former it presents a strong external resemblance, differing however in its somewhat more elongated form, and in its larger size. The original specimens of *Pleurophorus gregarius* were described from the Lower Marine Series at Farley, and it is naturally to be expected that in the wide vertical separation of these from the Burrier specimens, some evolution would have taken place. The whole question however, seems to hinge on whether the Burrier specimens are *Pleurophorus* at all. With considerable trouble the hinge plates of two specimens were partially cleared, sufficiently, however, to show that if the cardinal teeth characteristic of *Pleurophorus* are present at all, they are smaller than in the type of *P. gregarius*. But if, as seems likely, they are not present, the

shell must be removed from *Pleurophorus* and placed under *Stutchburia* as a new species, which may then be termed *S. inflata.* With the other species of *Stutchburia* there is but little resemblance; for *S. compressa*, Morris, *S. Farleyensis*, Eth. fil., and *S. simplex*, Dana are much flatter and less elongate forms. The other Australian *Stutchburias* have radial striae on the posterior portion of the shell, and so cannot be considered.

STUTCHBURIA COMPRESSA, Morris sp. (Strzelecki's N. S. Wales and Van Dieman's Land, p. 274, pl. 13, f. 4).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. In writing of this genus, Mr. Etheridge says:—"Under *Stutchburia* come the two species *Orthonota? costata* and *Orthonota? compressa* of Morris, which may or may not be only the internal cast of *O.? costata.*[1] Specimens of *S. compressa* from Burrier are very well preserved, and confirm the opinion of Mr. Etheridge that the two species are distinct. Many examples are testiferous, and careful examination in every case failed to yield the slightest trace of any radial sculpture. The edentulous nature of the hinge line is very well shown in the specimen figured. A thickening of the hinge, just below the umbo of the right valve, may possibly mark the position of a rudimentary tooth. The test itself is very thick, much more so than in *S. costata.*

STUTCHBURIA COSTATA, Morris sp. (Strzelecki's N.S.Wales and Van Dieman's Land, p. 273, pl. 11, f. 1 and 2).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Two specimens were found, one testiferous, the other an internal cast. The cast shows traces of the

[1] Rec. Aust. Museum, vol. III, No. 7, 1900, p 178.

radiating sculpture, but on the other specimen there are 16 distinct radii. The test is very thin, and there is a fold or depression in the centre of both valves, which is absent in *S. compressa.* This depression reaches from the beak to the ventral margin, and is removed from the anterior extremity about one third of the length of the shell. The ventral margin is not unbroken as in *S. compressa*, but is curved inwards to meet this fold, the posterior side of which is occupied by the radii. There can be no possible doubt that the two species are distinct.

SOLENOMYA TRANSLINEATA, sp. nov.

Specific Characters.—Shell soleniforme, elongated posteriorly, moderately thin; posterior portion rounded on both margins, and gradually narrowing to its extremity which is also rounded. Anterior adductor impression small and shallow, while the posterior impression is hardly visible. There are two smaller linear impressions running parallel to each other just anterior to the umbos. Dentition obscure. On one cast a slight undulation is seen in the infilling of the sub-umbonal portion of the hinge region, representing an inflation in the hinge. The ornamentation consists of numerous very fine radiating striae, covering the whole surface of the shell. These are crossed by regularly placed and fairly deep growth folds. The number of striae counted within one half inch, measured in the centre of the valve varied from 26 to 30.

Dimensions—Length $1\frac{1}{3}$ inches; height $\frac{7}{16}$ inches; thickness of united valves $\frac{1}{4}$ of an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Eight specimens were obtained, both as casts and with the shell matter preserved. This species approaches *S. Puzosiana*, de Kon., *S. saginata*, de Kon., from the Car-

boniferous Formation of Belgium;[1] and *S. Edelfelti*, Eth. fil.[2] from Queensland in general form, but differs from the first two in its tapering posterior portion, and from all three by the very close nature of its radiating striae.

NUCULANA OVATA, sp. nov.

Specific Characters.—Test transversely ovate, elongated anteriorly and rounded posteriorly. The anterior border is slightly uplifted, short, straight, making an acute angle with the ventral margin, which is broadly rounded. Umbos nearly centrally situated fairly prominent and twisted anteriorly. Anterior adductor impression prominent, its cast being sharply ridged upon its dorsal border. The posterior adductor is shallow and situated high in the valve. Pallial line not visible, and hinge structure unknown. The ornamentation is concentric, consisting of about 35 regular sharp concentric ridges, gradually increasing in prominence to the ventral margin. The spaces between the ridges are smooth and deeply rounded. Anterior to the umbos, there is an elongated cordate and somewhat concave escutcheon, separated from the remainder of the valve by a prominent rounded ridge, upon which the ornamentation doubles and runs upwards towards the umbos nearly parallel to the dorsal margin, which at its anterior extremity is elevated, thus forming on the united valves a sharp ridge which stands above the escutcheon.

Dimensions—Length $\frac{3}{5}$ of an inch; depth $\frac{1}{2}$ an inch; thickness of united valves $\frac{1}{3}$ of an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Several specimens of this pretty little species were found in a good state of preservation. It differs from all the Australian members of the genus, approaching nearest

[1] Faune du Calcaire Carbonifère de la Belgique.

[2] Etheridge and Jack, Geology of Queensland, p 275, pl. 14, f. 6.

to *N. abrupta*, Dana,[1] from which species it differs in the more central situation of the umbos, and the much shorter nature of the anterior extremity, and also in the relative proportions of the length to the height; *N. abrupta* being much longer in proportion to its height than *N. ovata*. From *N. Waterhousei*, Eth. fil., which is a fairly common species at Gerringong, it differs principally in the ornamentation, and there are no other species with which it can readily be confounded.

SOLENOPSIS SP.

Description—Shell soleniforme, long and narrow, and somewhat expanded behind. Umbos small and situated near the anterior extremity. Dorsal and ventral margins parallel. Just anterior to the umbos the dorsal margin is somewhat elevated, and below this the marked anterior gape is slightly expanded. The posterior margin is also probably gaping. Posteriorly the test has a tendency to be keeled. The shell substance is somewhat thick for this type of shell, and the ornamentation is concentric but faint. The muscular impressions are obscure and hardly visible.

Dimensions—Length $2\frac{1}{3}$ inches; height $\frac{3}{4}$ of an inch; thickness of united valves $\frac{7}{16}$ of an inch.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Three specimens were found at Burrier, but not in a very good state of preservation, and owing to this, the species though evidently new is not yet named.

PLATYSCHISMA OCULUM, Sowerby. (Mitchell's Three Exped. into Int. of Aus., pl. 2, f. 3 and 4).

Loc. (1) Burrier (D), Grassy Gully (F); (2) Shoalhaven River near Nowra (Q).

Hor. (1) Wandrawandian Series; (2) Nowra Grits.

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[1] Geol., Wilkes' U.S. Explor. Exped., p. 698, Atlas pl. 7. f. 3.

Obs. Not common in the district; very few specimens found.

MOURLONIA STRZELECKIANA, Morris. (Strzelecki's New South Wales and Van Dieman's Land, p. 287, pl. 18, f. 5).

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. Only one specimen was found.

PTYCOMPHALINA MORRISIANA, McCoy. (Ann. Mag. Nat. Hist., 1847, xx, p. 306, pl. 17, f. 5).

Loc. Burrier (D); Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. Numerous fine testiferous examples were obtained from Burrier, where it is very abundant. It is also common at Grassy Gully.

CAPULUS SP. indet.

Description.—A small shell belonging to the coiled section of this genus was the only specimen found. The body whorl is comparatively large, inflated and rounded, and there is a small closed spire of two whorls. The specimen is a somewhat poor one, and the ornamentation is not determinable, but apparently the shell is practically smooth.

Loc. Burrier (D).

Hor. Wandrawandian Series.

Obs. This is an interesting addition to our list of Permo-Carboniferous gasteropods, for if further specimens be found, it will almost certainly prove to be new. With two European species it bears a very strong resemblance, particularly *C. ? invicta*, Whidborne[1] from the Devonian formation of South England. To *C. inconstans*, de Kon.,[2] from Belgium, it is also very similar.

[1] Whidborne, Monograph on the Devonian Fauna of the South of England (Palæontological Society, 1891), pl. 19, figs. 13 and 13a.
[2] De Koninck, Faune du Calcaire Carbonifère de la Belgique, pl. 47, figs. 10 and 11.

EUOMPHALUS? SP.

Loc. Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. One specimen was found, consisting of the internal cast of a small four whorled shell, with spire depressed below the later whorls. As far as can be ascertained the surface of the shell is smooth.

CONULARIA INORNATA, Dana. (Geol. Wilkes' U. S. Explor. Exped. 1849, p. 709, pl. 10, f. 6).

Loc. Grassy Gully (F).

Hor. Wandrawandian Series.

Obs. Several good specimens of this handsome species were found at Grassy Gully. One of these, similar in other respects is rhomboidal in section. This may be due to crushing. The determination of species of this genus is very difficult and not always satisfactory, unless specimens are very well preserved. Thus all the Shoalhaven specimens are retained under *C. inornata*, in spite of some difference in minor characters, such as angle of section etc.

AGATHICERAS MICROMPHALUS, Morris. (Strzelecki's New South Wales and Van Dieman's Land, p. 288, pl. 18, f. 7).

Loc. Burrier (D); Shoalhaven River (E).

Hor. Wandrawandian Series.

Obs. This species is common at Burrier, while three specimens were obtained from the latter locality.

(2) **Devonian**.—The Devonian fossils found on the Shoalhaven River were for the most part very badly preserved, and it was quite impossible to name the majority specifically; in fact in some cases, particularly in the case of the pelecypods, even the genera are uncertain. However, as no Devonian fossils have ever been recorded from the district with the exception of *Lepidodendron* from Yalwal,

the specimens procured are here tabulated. Very little is known about the mollusca of Australian Devonian rocks, in fact, less than of any other Palaeozoic formation. That an abundance and fair variety must have existed is however incontrovertible. The numerous species of Silurian molluscs described from Yass and Wellington in New South Wales and from Lilydale in Victoria, show that period to have had a rich molluscan fauna: and as the Carboniferous formation has been equally productive, it is inconceivable that the intervening period was barren of this type of life. However the fossils here listed, in spite of their bad preservation, will serve to show that such a variety did exist. And this fact in itself supplies another reason for their rarity as fossils. The conditions during Devonian times were evidently very unfavorable to their preservation. The abundance of sandstones and quartzites seems to point to the predominance of shallow water conditions over large areas, a state which would be more favorable to the existence of a brachiopod than a molluscan fauna. The practical extinction of the brachiopods has, in later ages, led to the development of a littoral series of molluscs; but in Palaeozoic times it is evident that the predominent type of shallow water shells were the brachiopoda, while the majority of the gasteropods and pelecypods preferred the calmer and deeper waters removed from the shore. There is at least one locality known to the author, where these conditions prevail; and a series of Devonian limestones contain, beside a number of corals, a rich series of molluscs. Brachiopods are also abundant, but the typical sandstone forms, *Spirifera disjuncta* and *Rhynchonella pleurodon*, are absent. This locality is near Lake Bathurst railway station, and will be dealt with at a future date. Here it is merely mentioned as some illustration of the distribution of the Devonian fauna. At the present time also, additional localities are continually coming to light, and Devonian

limestones on the Murrumbidgee River and other districts, are gradually yielding their molluscan fauna to the collector.

The Shoalhaven specimens obtained on the earlier collecting tours, were kindly examined by Mr. W. S. Dun, and the majority of the determinations are his. Further material has led to some slight modifications in nomenclature, but the names must still for the most part be regarded as provisional.

LEPIDODENDRON SP.

Loc. Yalwal Creek (P).

Obs. Fair impressions of the stems of a Lepidodendroid plant are fairly common in this locality.

MONTICULIPORA SP.

Loc. Yalwal Creek.

Obs. Several specimens were found in boulders in the bed of Yalwal Creek.

SPIRIFERA DISJUNCTA, Sow. (Trans. Geol. Soc. London, v (2), 1840, pl. 53, f. 8; pl. 54, f. 12, 13).

Loc. Shoalhaven River (K); Grassy Gully (G).

Obs. Specimens at K were found in situ. At G they were found in a quartzite boulder above the junction of the Devonian, and the Upper Marine Series (see former paper).

RHYNCHONELLA PLEURODON, Phill. (Geol. Yorkshire, 1836, II, p. 222, pl. 12, f. 25–30).

Loc. Grassy Gully (G).

Obs. Found with *Spirifera disjuncta* in this locality (see former paper, page 321).

ALLORISMA ? SP.

Loc. Yalwal Creek (P).

Obs. This shell is exceedingly common in this locality, whole masses of rock being made up of its remains, but in

spite of its abundance no specimens were found sufficiently preserved to even name the genus with certainty.

GONIOPHORA SP.

Loc. Shoalhaven River (K).

Obs. Several specimens were found.

SPHENOTUS SP.

Loc. Yalwal Creek (P).

Obs. Three specimens were obtained.

LEPTODOMUS SP.

Loc. Yalwal Creek (P).

Obs. Four specimens were found.

PTERINEA SP.

Loc. Yalwal Creek.

Obs. Several specimens of a large species were found in boulders in the bed of Yalwal Creek.

CTENODONTA SP.

Loc. Shoalhaven River (K).

Obs. Only one specimen was found, and in the absence of the hinge it is impossible to name it with certainty.

BELLEROPHON SP.

Loc. Shoalhaven River (K).

Obs. Internal casts, probably belonging to two species, are fairly common in some horizons in this locality. No characters are however sufficiently preserved to give them their correct specific positions, or even to hint at their affinities.

EUOMPHALUS ? SP.

Loc. Shoalhaven River (K).

Obs. Internal casts of an euomphaloid shell, with three rounded whorls, low spire and small umbilicus are common, associated with the specimens of *Bellerophon*.

NATICOPSIS ? SP.

Loc. Shoalhaven River (K).

Obs. One poor cast was found, which may belong to this genus.

NOTES ON "A WHITE AUSTRALIA."

By A. DUCKWORTH, F.R.E.S.

[*Read before the Royal Society of N. S. Wales, August 3, 1910.*]

The Monroe Doctrine.—So long ago as December 1823, President Monroe, in his annual message to the Congress of the United States, made the statement that "we could not view an interposition for oppressing the South American States, or controlling in any other manner their destiny, by any European power, in any other light than as a manifestation of an unfriendly disposition towards the United States." Thus was the famous Monroe doctrine formulated, which has since formed the rule for foreign intercourse recognised by all parties in America. At the time, the United States had but a population of some $9\frac{1}{2}$ millions, and in the circumstances, this notable declaration of President Monroe, as expressing an ideal policy, was one which has increased in importance with the lapse of years. Now, in our own continent of Australia, it has been laid down as a principle, that our Australian territory should, presumably chiefly in the interests of the working classes, be reserved for people of the white races,—in other words, that a "White Australia" is necessary. As regards the purely political or party aspects of this question we have nothing to do. There lies before us the wider economic problem, whether the policy of a White Australia is feasible in fact, in view of the present nature of the existing population and of the diversified range of climates in Australia, and of the proximity of coloured races to its shores. On the question in its climatic and physiological aspects there have been expressed very divergent opinions. It is of vital importance therefore, that scientific inquiry be brought to

bear upon it, so that some reasonable grounds for final decision may be formulated without undue tardiness. Unless Australians have definite and enlightened views upon this problem, the mother country herself can hardly be expected to grasp what we may wish should be done in the interests of the federated States, to whom she has entrusted the destinies of this immense continent, which a late Governor General, Lord Northcote, recently stated would easily support a population of 50 millions. The subject for our investigation is, how can the tropical and sub-tropical areas which constitute a considerable proportion of Australian territory, now under the control of a white population, be effectively developed, and by whom? If not by white people, do we need to consider the advisableness of admitting Indian, Chinese, Javanese, Japanese, or Kanaka labour to our shores, and on what terms? Has a foreign immigrant any legal right to enter Australia except upon the direct authority of the Australian people? and are Australians under any responsibility to accept immigrants from other shores?

Alien Immigration.—An American authority[1] puts the legal position in the following way:—

"If any government deems the introduction of foreigners or their merchandise injurious to the interests of their own people, they are at liberty to withhold the indulgence. The entry of foreigners and their effects is not an absolute right, but only one of imperfect obligation, and it is subject to the discretion of the government which tolerates it. . . . . I am of opinion that every government has the right, and is bound in duty to judge for itself, how far the unlimited power of admission and residence of strangers and immigrants may be consistent with its own local interests, institutions and safety."

If this be conceded, then there appears to be no legal or moral responsibility resting upon Australians to allow

[1] Kent's Commentaries on American Law, Vol. I.

immigrants of Chinese or other nationalities to land upon our shores, although, on the other hand, Australians as British subjects have claimed the right to enter China, somewhat inconsistently.

The powers vested in the Governor of a State, as representative of the Crown and head of the executive government of such State, form the sole basis of constitutional government in the dependencies of Great Britain exercising responsible self-government under a proper "Constitution Act." Now in considering first, the legal aspect of the White Australia question, we need only refer to the well-known case of Chun Teong Toy *v.* Musgrove (Collector of Customs) under the Chinese Act, 1881, of Victoria. In this case Toy, one of a number of Chinese immigrants, was not allowed to enter that colony, although the poll-tax of £10 was tendered on his behalf; the Supreme Court of Victoria, being called upon, decided in applicant's favour, and damages were awarded to the extent of £150. Chief Justice Higinbotham was one of the minority of the Judges. The case was however carried to the Privy Council, with the result that in terms of the judgment of the Lord Chancellor, "No authority exists for the proposition that an alien has a legal right, enforceable by action, to enter British territory."[1] The sovereignty of the colony, within the limits of the Constitution Act of 1855, was thus upheld, and the position taken up by the Collector of Customs in interpreting the Chinese Act, as practically preventing any excessive numbers of Chinese aliens from landing in the colony and not merely involving the imposition of a tax on those desirous of entering it was maintained. The prerogative of the Crown to exclude aliens, either friends or enemies was upheld, as being in accordance with international law. In 1290, Edward I. expelled the Jews from

[1] Law Reports, Appeal Cases, 1891.

England. Would not Australians be justified in expelling any convicts from New Caledonia entering the Commonwealth without lawful authority? Self-preservation is the first law of nations, as of individuals. Yet it comes upon one with some degree of surprise, that one of the Victorian Judges (Mr. Justice Hartley-Williams) expressed an opinion on the case as follows:—

"I have been for years, in common with, I believe, very many others, under the delusion (as I must term it) that we enjoyed in this colony (Victoria) responsible government in the proper sense of the term. I awake to find, as far as my opinion goes, that we have merely an instalment of responsible government. . . . . We are at present without the *legal* means of preventing the scum or desperadoes of alien nationalities from landing on our territory whenever it may suit them to come here."[1]

It will be evident that very serious questions were involved in the case of Toy, some of which remain in doubt probably to the present time; for the judgment delivered by the Privy Council (as already set forth) does not enter into any consideration of the wide questions discussed in some of the individual judgments of the Supreme Court Bench in Victoria. To what extent these questions may be modified, if at all, by the later inauguration of the Commonwealth is not yet apparent.

Virility of Australians.—Passing on however from this purely legal aspect, to the wider question of the physical fitness of the white races for the successful colonisation of Australia, there is a preliminary but important and pertinent inquiry which needs to be instituted, as to whether the present white population of the southern portions of Australia is maintaining its virility and improving in stamina, or is it deteriorating from the parent stock? It would appear, on the surface, hardly necessary to discuss

[1] Vide Victorian Law Reports, Vol. xiv, 1888.

such a question. Yet a certain section of our people have their misgivings, and sometimes succeed in imbuing visitors from other lands with their pessimism. A Melbourne newspaper, only a month or so ago, adverted to the climatic conditions of New South Wales[1] as being the cause of a "very remarkable phenomenon," a reduction of lung capacity in the native born, owing to the mild winters in that State; the result being that "by the time the Australian native in New South Wales has reached manhood, he has quietly dropped out about a sixth part of the lung accommodation that the Briton and American naturally provide." Now on this question of racial stability we have at hand tolerably good evidence in the successul operations of the life offices of Australia during the past sixty years.

Life Assurance Results.—One of the most important investigations in Australia into the mortality of assured lives is contained in the "Mortality Experience of the A.M.P. Society" (1849 – 1888). In this report, Mr. Teece stated on p. 34, that—

> "The experience of the A.M.P. Society has been more favourable than that of either of the American offices, or of the 20 British offices represented in the $H^{M\,(5)}$ table," and it seems to "conclusively prove the superiority of our lives over those embraced in the experience of the 20 British offices," whilst in future it is "equally clear that it will not be more favourable than that of the best old British offices."

This favourable result does not however necessarily ensue when we compare the death rates of the general population. One important feature of the mortality of a general population is the rate experienced during the first five years of life. The following table, published in a paper read by me in 1894[2] institutes a comparison which results favourably in the case of the populations of Sydney and Melbourne:—

[1] Leading article in *Age*, 16th June, 1910.
[2] "Insurance and Banking Record," September 1894.

Table A.

Probability of dying in first five years of life.

	England 1876 – 1880. (Humphreys)		Sydney and suburbs 1881–1890	Melbourne and suburbs, 1881 – 1890.		
Age.	Males	Females.	Males and females.	Males.	Females	Persons.
0	·157	·127	·169	·190	·170	·181
1	·060	·057	·052	·054	·051	·052
2	·033	·032	·016	·018	·019	·019
3	·022	·022	·011	·014	·013	·013
4	·017	·016	·009	·012	·012	·012

General Population Statistics.—Also in the same paper is given a comparison of the "expectation of life" at all ages in New South Wales and Victoria, as compared with that ascertained for Sydney and suburbs and for Melbourne and suburbs, respectively. The following results were disclosed based on the census of 1881 and 1891 and deaths in the years 1881 – 1890:—

Table B.

Complete Expectation of Life (Males and Females).

Melbourne and Suburbs.		Sydney and Suburbs.
Age 0	40·86 years	43·39 years.
„ 5	49·67 „	51·62 „
„ 15	41·66 „	43·26 „
„ 25	34·15 „	35·48 „
„ 35	27·47 „	28·44 „
„ 45	21·30 „	21·91 „
„ 55	15·67 „	16·04 „
„ 65	10·75 „	10·97 „
„ 75	6·85 „	6·92 „

This showed the comparatively superior longevity of the people of Sydney and suburbs over those of Melbourne and suburbs. The combined table for New South Wales and Victoria at the same dates showed still better results ; so favourable indeed that they may be compared with the specially prepared English mortality table (for healthy districts only) first published by Dr. Farr in 1861 :—

Table C.

Complete expectation of life New South Wales and Victoria.		Complete expectation of life by Healthy Districts life table.
Age 0	49·37 years	49 0 years (Farr)
„ 5	54·39 „	54·16 „
„ 15	45·99 „	47·12 „
„ 25	38·04 „	40·05 „
„ 35	30·80 „	33 17 „
„ 45	23·79 „	26·05 „
„ 55	17·24 „	18·86 „
„ 65	11·44 „	12·29 „
„ 75	6·95 „	7·34 „

Considering the "select" nature of the English table, the Australian results—in which accidental deaths are a feature as in all new countries—were distinctly satisfactory from a comparative point of view. The average death rate is, obviously, not the result of a natural law which cannot be altered; scientific discovery has made wonderful advances within the last quarter of a century, and has pointed out the ways in which longevity may be fostered, and death be postponed in many cases.

Public Schools Report.—It will be advantageous therefore, to consider what has been the most recent experience of our own State not as regards mortality, but more especially in regard to the physical development of the children, and on this point we have an elaborate Government report relating to over 30,000 children attending Public Schools in Sydney, Newcastle, etc., published in 1908, and a further report for 1908-9 dated March 1910.[1] On the very important point of "weight," this report states that the averages for girls and boys compare favourably with those of England, Scotland and America. The tallest children, it is stated, come from the central tablelands (Bathurst

[1] The report for 1908-9 states that "the general results show the averages in height and weight are somewhat higher, age for age, than those recorded for last year," vide p. 5.

district), but are lighter in weight than children from the sea-side. The British boy, we learn, is shorter but heavier from ages 8 to 13, and again at ages 16 to 17, but at other ages the New South Wales boy is a little heavier. The following table from the report gives the average height and weight as follows:—

Table D.

Physical condition of school children at Public Schools in N.S. Wales.

(Table published in 1908 by the Public Instruction Department.)

New South Wales Boy. (19,885 records.)					N. S. Wales Girl. (16,965 records).				A.M.P. Comparative Experience (Lives).				
Age last Birthday	Height.		Weight.		Height.		Weight.		Age last Birthday.	Weight.		Chest measurement	
												Expir.	Inspir.
	feet	inches	stones	lbs.	feet	inches	stones	lbs.		st.	lbs.	inches.	inches.
4	3	3	2	9	3	2	2	8	4				
5	3	5½	2	12½	3	5	2	11½	5				
6	3	7½	3	2½	3	7½	3	1	6				
7	3	10	3	6½	3	9½	3	5½	7				
8	4	0	3	11	3	11½	3	10	8				
9	4	1½	4	1½	4	1½	4	0½	9				
10	4	3½	4	6½	4	3½	4	6	10				
11	4	5½	4	12	4	5½	4	12	11	4	13	23·7	26·2
12	4	7	5	3½	4	7½	5	6½	12	5	2	24·2	26·8
13	4	9	5	11	4	10	6	3	13	5	11	25·4	28·0
14	5	0	6	9	5	0	6	12	14	6	5	26·0	28·6
15	5	2	7	5½	5	1½	7	6	15	7	0	27·2	29·9
16	5	4½	8	6½	5	2	7	11½	16				
17	5	6	9	1½	5	2	8	0	17	8	7	29·8	32·7
18	5	6½	9	8	5	2½	8	3	18				

For purposes of further comparison I have added the figures relating to weight and chest measurement of children accepted for assurances by the A.M.P. Society at ages 11 to 17, taken from an unpublished anthropometrical table of the Society, as computed by Mr. Teece in 1906. With the evidence thus before us it may be hoped that public interest in the matter will be stimulated, and that the experience of other states and institutions will in course of time be forthcoming for comparison and analysis.

If it be found that the development of our native-born population presents satisfactory features as a whole, at least in those portions of the continent enjoying temperate climates, what shall be said regarding the effects upon the white population of residence in the semitropical regions of the continent? These effects may, in part, be measured by a comparison of the death rates and rates of mortality experienced in Australia.

Now the Year Book of the Commonwealth gives the death rates in 1908, per 1,000 living of the mean population in the various States and New Zealand as follows:—

	Death rate per 1,000 living:	
New Zealand 1808	9·9	
South Australia	9·96	
New South Wales	11·01	
Queensland	11·69	
West Australia	11·69	
Tasmania	11·90	
Victoria	14·04	
Mean rate for the Commonwealth	11·94	in comparison with
England and Wales 1907... ...	15·0	
Scotland	16·2	
Ireland	17·7	

From this table the excellent position of Australia and New Zealand, as compared with the United Kingdom will be evident. Queensland and West Australia occupy a relatively higher position than Victoria does with its admittedly temperate climate.

Queensland Mortality Rates.—There was a time when it was considered that residence in Queensland entailed an extra risk, to cover which, life insurance offices exacted an extra premium, often amounting to 10s. per annum per £100 assured. This extra premium was discontinued by the

A.M.P. Society after an investigation into the rates of mortality experienced by the Society in Queensland during the period from 1875 to 1888 inclusive. Mr. Teece in his investigation report of 1894, summarised the results by stating that—

"The mortality among Queensland members has been higher than among the general body of the lives assured, but the excess is not sufficient to cause any anxiety. . . Many of the conditions which tended to make life in Queensland precarious 20 years ago have disappeared, and in a comparatively short time few of them will remain. It is difficult to say what is the extent of the improvement which has in recent years been effected in the vitality of the Queensland colonists."

In Queensland the percentage of actual deaths of assured lives was only 83 per cent. of those expected by the British H^{M} mortality table, although some 16 per cent. in excess of the deaths throughout the whole Society. Can it be said in view of these Queensland results that the white race need fear the future experience and development of the race in that progressive State? It is impossible to believe that, in Australia, the present small white population alone can for many years effectually stem the tide of an alien, if peaceful invasion, flowing in where there is room to live in the idle spaces of our land still in a state of nature. This question was discussed at the Adelaide meeting 1907, of the Australasian Association for the Advancement of Science (Vol. XI), when a paper was submitted by Mr. Matthew Macfie of Melbourne.

Tropical Australia and its development.—In this paper reference was made, *inter alia*, to the physical effects of excess of *light* on the white races in tropical and subtropical climates, and the argument deemed to be impregnable, was used that "the white man does not get inured to the sun, and each climate is exactly suited by natural

law to the particular human racial type evolved under its influence, but cannot be adjusted to any other." Professor Baldwin Spencer is therein quoted as having said, "In my opinion there is a belt of country in tropical Australia—the northern territory of Queensland—which can only be worked with the aid of coloured labour." A Vice-President of this Society, the late Dr. Walter Spencer, is quoted as having stated that "If one maintains that the agricultural riches of tropical Australia can be developed by white labour, he is either a deluder or is deluded."

In this Society also we have had a thoughtful paper by Mr. Joseph Palmer on "A White Australia," which is included in the records of its Economic Section. The paper was read in September 1901, and in it reference was made to the Bill then before the Commonwealth Parliament, which subsequently became law as the Aliens Immigration Restriction Act of 1901, it being subsequently amended in 1905. Under this Act, any person other than European, is prohibited from entering the Commonwealth who fails to pass the "dictation test," *i.e.* "who fails to write out not less than 50 words of a European language prescribed by regulation, when dictated to him by an officer administering the Act."[1] Mr. Palmer held the view that it is the duty of Australians "as trustees in possession of this vast territory, to govern it and its inhabitants in the best interests of the entire human race," and that the theory of a White Australia is "unjust, undesirable and impossible—impossible, because legislate as much as we may, we cannot keep the black and coloured people out." These are statements of a sufficiently definite character to cause us to consider if there be nothing to urge on the other side of the question. Mr. Macfie, already referred to, has recently

[1] An amending Bill is now before the Federal Parliament, increasing the stringency of existing legislation and incidentally allowing the dictation test to be imposed at any time within five years of landing.

read a further paper on the subject before the Royal Geographical Society in Melbourne, wherein he approves a suggestion of Professor Osborne,[1] of Melbourne, that a committee of experts should be appointed by the Federal Government, or the Northern States, to make investigations in Australia and Papua as to whether whites or coloured persons under white supervision are best adapted for the effective development of Australian resources. Now we do not propose in this paper to quote from any utterances of prominent Australian politicians on this subject, as probably being deemed biassed. What then is the nature of the testimony which can be adduced in favour of the White Australia theory, apart from statistical facts such as have already been referred to?

In favour of White Australia.—Professor J. W. Gregory formerly of Melbourne University, has expressed the opinion that there seems to be no adequate reason why Australia should not in time all be occupied by white races. He has devoted much thought and study to Australian conditions, and in February last read a paper entitled "The Geographical Factors that control the development of Australia."[2] "Travel and Exploration," a London monthly, in its issue for April, contains an appreciative notice referring specially to the circumstance that the author had shewn that the increase of population in Australia, though often popularly regarded as disappointingly low, had really been unusually rapid. He compared it with progressive and much belauded Canada, and pointed out that it took the dominion two and a half centuries to reach the population that Australia had secured in less than one. Then on the burning question of coloured labour, as opposed to white labour, in Queensland, Professor Gregory is con-

[1] Professor Osborne's paper on the "Problem of Tropical Colonisation," appeared in the *Argus* of 10 April, 1909.
[2] The *Geographical Journal*, June 1910.

sidered to have conclusively proved that, contrary to general opinion, the tropical regions of Central Australia can be more effectively, and actually more cheaply developed by white labour than by kanakas. Actual experience and theoretical considerations therefore it is said show alike that there is nothing in the climate of tropical Australia to prevent its colonisation by white races.

Professor Gregory also suggested that—

"The northern peninsula of Western Australia, the north-western corner of Queensland, and the Northern Territory," (which he considered to be the weakest point in the Australian position) "would together form a great tropical territory with a convenient and natural boundary. Its government would train a staff expert in its special tropical problems, and in twenty years time it would be possible to tell whether the colonisation of the country by a white race is practicable within a reasonable time."

Dr. Ramsay Smith, head of the department of Public Health of South Australia, stated in the course of discussion of Mr. Macfie's paper at Adelaide in 1907:—

"There is nothing so far as I can find, in the whole science and practice of medicine, to show that white men, as individuals or races, cannot live in the tropics. On the contrary, all the facts of hygiene tend to prove that they can."

He also stated that science has shown that the black possesses no immunity from malaria, but is in a condition to pass the disease on through the medium of the mosquito to the white man; that persons whether indigenous to the tropics or immigrants to those regions will develop pigment naturally; that the question of white and black labour in the tropics is a commercial one, not one of health, and he deprecated any attempt to support any side of a commercial argument by bolstering it up with scientific fallacies and illogical arguments. Other medical men with tropical experience have held that mere residence in a hot dry

climate will, in the course of time, turn the skin brown, whilst a hot humid climate will turn it black. As to the capacity of Australians to develop pigment we need only to visit one of our coastal beaches in the height of the surfing season. Concerning the medical aspect I shall have something to say later. Only the other day[1] a prominent Sydney journalist (Dr. Ward), opposed any theory that "the further north one went in Australia, the weaker the white men were, and the further south the stronger they grew." We may remark that, as regards the aborigines of Australia it is perhaps admitted that the most vigorous of all are those of the north,[2] but may not this be partly due to the circumstance that affects nomadic tribes so much, namely the abundance of food produced by nature, in prodigal mood, in the tropics, and the absence of rigorous cold in the winter. These conditions would necessarily not affect to the same extent civilised people of white extraction. The contiguity to Australia of lands where coloured races occupy the earth as already stated, renders the problem in Australia more acute.

Defence of Australia.—We may quote in this connection and by way of exception, the recent trenchant remarks of Senator Pearce, the present Commonwealth Minister of Defence, who in a speech at Melbourne during last month[3] said that—

"The whole national fabric depended upon our ability to keep this country for the white races of the world. Whilst he believed in arbitration, it was no use shutting our eyes to the fact that a nation which cast envious eyes on Australia would not be prepared to submit the future of this country to any arbitrament but that of force, if it once made up its mind to attack it."

[1] *Sydney Morning Herald* of 20 June, 1910.

[2] A writer in the *Sydney Morning Herald* of 8th July, states that "the Territory blackfellow is the finest race of aboriginal in Australia; big, strong, strapping fellows capable of great endurance," yet becoming lazy and depraved by mixing with the Chinese.

[3] Melbourne *Age* of 8th June, 1910.

Tropical Islands adjacent to Australia.—North-west of Australia and south-east of Asia lie the islands of New Guinea, Borneo, Celebes, Sumatra, Java and the Malay peninsula, etc., not to speak of Ceylon on the one hand and the Philippines on the other. Here we find a mixture of races indeed. In Java and Sumatra strenuous work is almost unnecessary, since nature is so prodigal of her bounty. In the former island alone a population of some 30 millions exists; from the land with a rainfall of some 200 inches per annum, sugar is the main article produced. The invasion of the islands under Dutch sovereignty by Chinese, is stated to be a growing one. In Fiji there are large numbers of Indian coolies engaged in the sugarcane industry. All this means possible complications for Australia. We have shut the Chinaman out, but in Queensland they are said to be still increasing, and although they cannot own land, yet it is stated that on the Atherton tableland to day—where assuredly the white races should be able to hold their own—Chinamen are leasing lands from the owners and paying a rental of £1 per acre, whilst the half-caste population is apparently growing in numbers.

Northern Territory Lands.—Consider now the vast field for future colonization in Australia, which is evidenced by the existence of such areas, for example, as the Barclay tablelands of the Northern Territory, between the overland telegraph line and the Queensland border, comprising an estimated area of 37,000 square miles, even now almost a *terra incognita*. Mr. W. M. Burton, a recent writer,[1] says "there is no finer grazing land perhaps in the world," having a rainfall of from 16 to 23 inches per annum, in different localities, and abundant reservoirs of sub-artesian water, whilst the summer heat is a dry heat comparable to

[1] *Dalgety's Review*, 1 Sept. 1909, also compare a series of articles in *Sydney Morning Herald*, 8 July 1910, and succeeding days.

that of Bourke in the west of New South Wales. As regards the Northern Territory as a whole, it has a coast line of 1,200 miles, yet is without agriculture after 40 years of partial occupation, its rainfall being 60 inches in the wet season from October to March.

Central Australia and its Climate.—Again there is the much decried Eremian, or solitary desert region in Central Australia, explored by the W. A. Horn expedition in 1894, an area some 1,600 miles long by a width of 800 miles, with an average rainfall of but 5 to 12 inches[1] per annum, similar in extent to that of the Coolgardie goldfields, with frequent periods of drought; yet in the neighbourhood of the MacDonnell Ranges, rising to an altitude of nearly 5,000 feet above sea level, the rapidity of vegetable growth is stated as being almost marvellous, following upon tropical rains, leading to inundation of the surrounding country by reason of the immense volumes of water rushing down from the hills.[2] Another recent feature is that of the striking of underground water at Eyre on the proposed trans-Australian railway route, regarding which Sir John Forrest has expressed the opinion that this discovery of sub-artesian supplies adds a province of 15 million acres of limestone country to West Australia. Australia, be it remembered in this connection, is to-day as near England in point of time as Land's End was to John O'Groat's a century ago. Long after the middle of the eighteenth century communication between London and Glasgow was maintained by stage coach, which travelled once a month and accomplished the journey in twelve or fourteen days. During the winter, travelling was often impossible.

South African Racial Difficulties.—Nowadays Australians cannot forget that Queensland alone is half as large

[1] Contrast this for instance with the rainfall of Papua, where at Port Moresby it averages between 160 and 170 inches per annum.
[2] W. A. Horn in *Proc. Roy. Col. Inst.*, Vol. XXVII.

again as France and Germany put together. And as regards population we have only to compare that of Australia and New Zealand, some $4\frac{1}{2}$ millions and over 1 million respectively, with that of South Africa, where in the four now unified colonies about 1 million whites only are confronted with the existence of a coloured population of 4 millions; who, so far at least as the colonies other than Cape Colony are concerned, have been excluded from the franchise. The British House of Commons in its discussion of the Union Act, however, was at first inclined to condemn this erection of a rigid colour bar as being contrary to both the spirit and traditions of the British Empire. Here are present the elements of racial and political relationship pregnant with possibilities for the future. Is it not advisable therefore that in Australia some authoritative statement should soon be made so as to render free from reasonable doubt the best methods of settling the northern portions of Queensland, South Australia and West Australia. The London *Times*, according to a cablegram which appeared in the Sydney newspapers on 11th July, holds that—

"The overshadowing Australian problem relates to the huge, rich unpeopled northern territories. There is need for a rapid awakening of Australian opinion on this vital issue, and Australian politicians should realise that they are merely stewards for the rest of the world."

Will Australia soon be called on to account for its stewardship?

Sugar Industry.—Involved in the question is the future of an important industry, that of sugarcane producing, which is now protected in the interests of white labour to the extent of £5 per ton as difference between the import excise and bounty rates. The conference resolved to urge that a Royal Commission be appointed to inquire into the sugar industry.[1] The Prime Minister on 4th July last explained

[1] Article by Professor Gregory, "Nineteenth Century." Feb. 1910.

that it was proposed that the arrangement for payment of bounty and collection of excise should remain undisturbed on the present basis under the acts expiring by effluxion of time on 1st January, 1913; excise being payable at £4 per ton on all manufactured sugar, and a bounty being payable to growers of cane by white labour at the rate of £3 per ton of sugar produced. But there are other considerations to be borne in mind in relation to the general question.

Development of Civilization.—One of the most recent deliverances on the subject of tropical regions is a paper by Professor R. De C. Ward,[1] of Harvard. It contains the following startling statement concerning Australia: "Most of the latter continent (Australia) is a trade wind desert, and therefore hopelessly arid." It is rather surprising to find a statement of this character emanating from such a source. Professor Ward says:—"Experience teaches that white men cannot with impunity do hard manual labour under a tropical sun, but they may enjoy fairly good health as overseers, or at indoor work if they take reasonable precautions." It follows, in his opinion, that in tropical regions it is impossible that successive generations could go on reproducing white men and women without physical, mental and moral degeneration. It has, however, been pointed out that "prehistoric man in his earliest stages, when most helpless, was an inhabitant of the tropics." It is also in the tropics that animal and plant life reach such full development, and where nature does so much for primitive man that he needs do but little. Mr. Benj. Kidd in his "Control of the Tropics," says, "slowly but surely we see the seat of empire and authority moving like the advancing tide northward. The evolution of character which the race has undergone has been northwards from the tropics." But in this connection it would seem, in

[1] "Popular Science Monthly," for March 1910.

regard to some writers, that the temptation to be picturesque rather than to be strictly accurate must be considerable. If man originally came from the tropics, we may assume that his physical environment was then suitable, and that time must have been a very important element in connection with his gradual adaptation to new conditions in sub-tropical, temperate, and finally the colder regions and snowy deserts of the earth. Herbert Spencer in his "Study of Sociology," says with regard to climatic changes of constitution, that "such changes can be brought about by slow spreadings of the race through intermediate regions having intermediate climates to which succeeding generations are accustomed little by little." Surely the conditions of peopling the cold regions by colonising races must have originally been as difficult as the task is now said to be of peopling the tropics with the white races. For fears are even now expressed that in Canada and Russia the long continued cold conditions in winter seriously militate against the white races, since man needs so much and nature is so inhospitable, and plant and animal life so restricted, that his utmost activity is necessary so that he may even continue to exist.

Tropical Diseases.—It may be admitted that natives of tropical countries are not injured by the sustained high atmospherical temperature in which they live, as their physical activity is attuned by custom and habit to their surroundings. A European requires to adjust himself to altered meteorological conditions. But, as Sir Patrick Manson, an eminent medical authority, has pointed out:—

"In the tropics, as in temperate climates, in the European and in the native alike, nearly all disease is of specific origin."

Germs of a parasitic nature are the source of nearly all disease, but these require certain conditions of temperature, certain media, and certain opportunities for their continued

multiplication. The same authority states[1]:—

"The more we learn about these diseases, the less important in its bearing on the geographical distribution, and as a direct pathogenic agency, becomes the rôle of temperature *per se*, and the more the influence of the tropical fauna."

Malaria for instance is by far the most important disease agency found in the tropics and sub-tropics, undermining the health of multitudes and predisposing to other diseases, and as to its source in native villages, Sir Patrick Manson[2] refers to the Anopheles mosquito which having bitten a person with infected blood, then becomes affected by the *Plasmodium malariæ*, and after biting other persons it infects them also with the disease. He says:—

"After some years, and after many re-inoculations by infected mosquitoes, the surviving original inhabitants gradually acquire immunity from malaria, and the parasite can no longer be found in the blood. . . Children born in the village have no immunity, and therefore, soon after birth, being bitten by the infected Anopheles, acquire the infection. In this way there is kept up in the village a permanent stock of infected Anopheles."

Dr. W. H. Deaderick says[3]—

"It is evident that if this cycle be broken at any point, infection cannot occur, and that if it were universally interrupted during a sufficiently long period of time the disease would be annihilated."

The author also refers to the success attending efforts to suppress the disease at Ismailia, where it was introduced in 1877, and made great headway during the period 1885–1902, but since 1903 the cases have fallen to 2% only of the annual average for 1885–1902.

Sir Patrick Manson says also,[4] "That there is a protective power in the human body against the plasmodium is

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[1] "Tropical Diseases," p. xv. [2] *Op. cit.*, p. 102.
[3] "A Practical Study of Malaria," 1909, Ch. 8. [4] *Op. cit.*, p. 85.

certain, otherwise spontaneous recovery from malarial infection could not take place"; and he refers to some self defending physiological element of the body, the daily variation of which by deficiency or debility causes the intermittency of malarial fever. This testimony leads one to enquire whether the white race, sprung from aboriginal stock of a tropical climate has, owing to the effect of change of environment, lost some portion of its original protective physical powers, and that this loss may possibly be repaired. Of course it may be said that man of the old times was but a child as compared with men to-day. But however this may be, as regards his mind and active stage of civilization, we are not precluded from the view that his physical condition was at least as vigorous and well developed as that of the average man to day.

Papuans and Polynesians.—Have we not at hand an important illustration in the Papuan and Polynesian races? The Polynesians (including the Maoris) are physically some of the finest specimens of the human race, and they and the Papuans are both of Asiatic origin; but the Papuans, or many of them, are said to have physically deteriorated, possibly by long residence in a malarial climate. The Fijians, who are said to combine the physique of the Polynesians with the language and colour of the Papuans, evidencing an ancient adjustment of racial conditions, are admittedly of magnificent physique; but this is to some extent accounted for by the fact that malarial fever is said to be unknown in Fiji. Are we to set down the differences between the Fijians and the Papuans as nothing more than essentially the results of malaria? If the darker race is now subject to its ill effects, and these effects can be combated, then may not the white races claim that similar results would follow in their case eventually? If so, then we may have to reconsider the sufficiency of such statements as

that already quoted, made by Dr. Woodruff,[1] a surgeon in the U.S. Army, after experience both in the Philippines and in the Southern States of America, that "each climate is exactly suited by natural law to the particular human racial type evolved under its influence, but cannot be adjusted to any other." We find also that a writer of such calibre as Benj. Kidd, in his well known work,[2] makes the statement that, "In the tropics the white man lives and works only as a diver lives and works under water." Yet he admits that the black races will make no development under native government; and further he says:—

"The great rivalry of the future is already upon us. It is for the inheritance of the tropics, not indeed for possession in the ordinary sense of the word, for that is an idea beyond which the advanced peoples of the world have moved, but for the control of these regions according to certain standards."—(Page 3.)

In his earlier work[3] he expressed the opinion that "the tropics must be administered from the temperate regions." Are we then to hold that in the tropical portions of Australia the white races are to constitute a ruling caste, merely utilising and supervising coloured labour? If this be not admitted, are we then reduced to accept the view expressed by Professor C. H. Pearson[4] in "National Life and Character" (Chap. 1), who predicted—

'A globe girdled with a continuous zone of the black and yellow races, no longer too weak for aggression or under tutelage, but independent or practically so, in government, monopolising the trade of their own regions and circumscribing the industry of the European."[5]

[1] Quoted in Mr. Macfie's paper previously referred to in this paper.
[2] "Control of the Tropics," p. 54.
[3] "Social Evolution," Ch. 10.
[4] *Cf.* F. List's views referred to further on.
[5] In the cables in the press of 26th July, reference is made to the new Japanese tariff coming into operation in July 1911, under which it is estimated that British goods to the value of nearly a million sterling annually will be excluded.

But that the coloured races have their own disabilities, and are also subject to the influence of malaria, is evidenced by the fact, pointed out by Sir Patrick Manson, that in Africa many of the Chinese labourers on the Congo railway had died of African hæmoglobimiric fever. These men were, equally with white men, outside their ordinary climatic environment, and their capacity of resistance to disease was doubtless less than that of white men in similar circumstances.

National Theories of Colonization.—Now, in the past, colonies peopled from European nations have been formed under three main conditions (1) as a possession or estate, to be exploited in the interest of the mother nation, such as Java in relation to the Netherlands; (2) as a necessary expansion of territory, such as that of France in Africa; and (3) as territories held as those under the dominion of the English race, on a basis permitting of the ultimate expansion of the colonies into States of the modern type by a scheme of federal authority, despite the many partial failures in bygone days. The German writer, F. List, says[2]

"England has got into her possession the keys of every sea, and placed a sentry over every nation." List further declared (p. 270) that "all Asiatic countries of the torrid zone will pass gradually under the dominion of the manufacturing commercial nations of the temperate zone; the islands of the torrid zone which are at present dependent colonies, can hardly ever liberate themselves from that condition; and the states of South America will always remain dependent to a certain degree on the manufacturing commercial nations."

On this point Mr. Kidd has remarked, that—

"Railing off of immense regions in the tropics, under the policy which has suggested their acquirement, regions tending in the absence of white colonists to simply revert to the type of States worked for gain. . . . to the exclusion of the rest of the world."

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[2] "The National System of Political Economy," 1884, p. 46.

This suggests the idea that, as already stated, the question has its moral side, that the evolution which is going on among the nations, is a social evolution, and one where the best interests of the world at large may be involved in the holding of the tropics by white races as a trust for civilization. If the coloured races are markedly inferior not only in civilization but in moral character, the greater or less development of which may well measure the future stability of the race, may it not be incumbent upon the white races, as the finest product of civilization, to undertake this development of tropical and sub-tropical regions in the best interests of the world, as witness already the work performed under British guidance in Egypt and in India. This is totally opposed to the idea current among some people in our day, that the government of a large native population means the creation of a permanent European caste, "cut off from the influence of the political and ethical conditions and social traditions which have been the source of the development of the European race."

Australian Sub-tropics.—We cannot, however, consider Australia in this connection as being truly tropical, except in very limited areas, if we mean by "tropical" regions of monotonous heat with a relatively high humidity leading to great rankness of vegetable life.[1] We cannot compare the hotter districts of Australia with the climate of Java, India, the Philippines, or Hawaii, for example, and other countries where the seasons seem not to exist since the variations of temperature are comparatively so slight. If we accept Goldwin Smith's dictum (referring to the British rule in India) that "no race can forever hold and rule a land in which it cannot rear its children"; are we to conclude that this condition holds for Northern

[1] Professor Gregory points out the fact that there is as yet no proof that any considerable tracts of Australia have wet beds, temperatures above the limit of 85° and 88°.

Australia? Even if it did, it may not follow that the white races would be finally ousted by climatic consequences? In this connection we need to remember the important fact pointed out by Professor Ward, that thousands of Italians for instance, go to the United States in the spring to work there during the warmer months and then return to the milder climate of Italy for the winter. Similarly incursions are made into Argentina in the harvesting season. It remains therefore a question for Australians to consider whether people from Southern Europe may successfully be invited to migrate permanently to Northern Australia. Have we here a clue to the great problem of the development of the sub-tropical regions of Australia? Is there not a moral necessity pressing upon us to develop in the best manner possible the resources, mineral, pastoral, and agricultural of the regions in the northern portions of our land now running to waste under ineffective management? The sustained high tropical temperature of our northern areas is not of that dangerous intensity created by the more humid conditions of the tropics, and the diseases which may be of special prevalence in warm climates are not, so far as we probably know, of that deadly nature which is experienced in other portions of the torrid zone. Young and healthy Australians, properly educated beforehand, regarding the risks and inconveniences of our sub-tropical areas, will surely be forthcoming even from our somewhat limited population, to supply the waste places of our land with that vigor, energy and national capital of endurance which is requisite for the development of every part of our territory; and if we should also seek a judicious admixture of other European nationalities accustomed to a warm climate, who shall say nay?

Study of Tropical Diseases.—We have already at Townsville an Institute for the study of tropical diseases, with officials fully acquainted with the results of research in

Equatorial Africa. Has the time yet arrived when, after a full investigation and discussion of the varied problems affecting the policy of a White Australia, it will be possible to announce certain definite conclusions based on scientific evidence which will convince the people of this country once for all as to the proper solution of a question which otherwise threatens to be the "riddle of the Sphinx" to them?

Australian Ideals of Government.—It has been well said by an English writer[1]:—

"Australia is no longer an uncertain region of adventure and romance, no longer a region of wide, rich, unpeopled spaces. . . . Few people would have ventured on the eve of Federation to prophesy that to-day the Commonwealth would be as undivided as it is on its policy of a White Australia, which unconditionally closes the door to the man of colour, or on a highly protective tariff, the initiation of an Australian Navy, and a scheme of national defence, even if by resorting to compulsory training. In these and other directions one has unmistakable evidence of the growing presence of virile individual Australian thought, which, while quite consistent with Imperial ideals, reveals that the Australian people are taking their future seriously, and are grappling with their problems according to their particular circumstances, and with a full sense of their responsibilities"

In conclusion, the aim of the paper now submitted for your consideration will have been attained, if the result should speedily follow that the question of maintaining a White Australia is definitely and decisively considered as a means and basis for the future national development of Australia.

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[1] London 'Money Market Review of 10 April, 1909.'

THE HÆMATOZOA OF AUSTRALIAN BATRACHIANS No. 1.

By J. BURTON CLELAND, M.D., Ch.M., and T. HARVEY JOHNSTON, M.A., B.Sc.

(From the Bureau of Microbiology, Sydney, N.S. Wales.)

[*Read before the Royal Society of N. S. Wales, August 3, 1910.*]

IN carrying out a systematic census of the hæmatozoa of Australian vertebrates, it is our intention to record from time to time the various species met with. In the present paper we propose to deal with *trypanosomes* in Queensland frogs and a *haemogregarine* in *Hyla caerulea*, White, from the Sydney district.

The following is a list of the various species of frogs searched by us but in which haematozoa were not found. The dates, localities and number examined are also given:—

Species.	Date.	Locality.	No
Hyla lesueurii, D.&B.	April 1910	Kilroy, Queensland	(1)
Hyla aurea, Lesson	Nov. 1910	Sydney	(1)
	Nov. 1910	Richmond	(7)
	Mar. 1910	Sydney	(8)
Hyla nasuta, Gray	Mar. 1910	Harrisville, Queensl.	(2)
Hyla affinis ?	Mar. 1910	Harrisville, Queensl.	(3)
Crinia sp. ?	Mar. 1910	Harrisville, Queensl.	(2)
Limnodynastes dorsalis, Gray	Dec. 1909	Sydney	(1)
—— *ornatus*, Gray	July 1910	Queensland	(2)
—— *peronii*, Dum. and Bibr.	Mar. 1910	Sydney	(4)
Pseudophryne bibronii, Günth.	July 1910	Queensland	(1)
Unidentified frogs	Mar. 1910	Harrisville, Queensl.	(2)

List of species in which haematozoa have been found by us:

Hyla caerulea, White—October 1909, Sydney, haemogregarines in two out of two specimens examined; Dec. 1909, Sydney, one examined (nil); January 1910, Sydney in one out of two examined.

Limnodynastes tasmaniensis, Günther—December 1893, Myrtletown, Queensland; trypanosomes present.

Limnodynastes ornatus, Gray? March 1910, Harrisville; trypanosomes present.

With the exception of the trypanosome and the haemogregarine to be described further on, we are not aware of any other haematozoa having been recorded from Australian batrachians. We are indebted to the kindness of Dr. T. L. Bancroft for all the films from Queensland frogs.

TRYPANOSOMES OF FROGS (Figs. 2 – 10).

We have received from Dr. T. L. Bancroft, a number of specimens of blood from Queensland frogs, and amongst them were two instances in which trypanosomes were present. One, a frog from Harrisville, in which well preserved trypanosomes were found with ease, was probably *Limnodynastes ornatus*, Gray; in the other, a slide dated "Myrtletown, December 3rd, 1893," in which the species of frog had been indentified as *Limnodynastes tasmaniensis*, Günther, only one or two specimens of trypanosomes were seen and the stain had faded, whilst re-staining was not very successful.

Description of the trypanosome from the Harrisville frog:—All the specimens examined were very similar in appearance, differing from each other, mainly in breadth. The posterior ends were gradually attenuated. The prominent kinetonucleus were far removed from this end, and close in front of each was the reddish nucleus. The protoplasm of the body stained a deep blue; occasion-

ally assuming a streaked appearance but no definite ribbing could be discerned. Sometimes small vacuolar-like spaces were noticed in front of the nucleus. The undulating membrane was very distinct and deeply folded; owing to the situation of the kinetonucleus it naturally did not occupy the posterior part of the parasite. The flagellum was strikingly visible, running along the edge of the membrane and usually crossed the body in its anterior portion; it ended in a well-marked free flagellum.

In view of the marked pleomorphism of *Trypanosoma rotatorium* (Mayer), as described by Laveran and Mesnil,[1] we hesitate to separate this trypanosome from that species. Nevertheless the wide geographical separation of the frogs of Australia from those of Europe, coupled with the probably enormous lapse of years since these species of trypanosomes or their hosts, now respectively occupying these localities, were associated, gives reason to suppose that future research may reveal specific differences between the parasites. This is supported by the fact that our specimens seem decidedly shorter than *T. rotatorium*, Mayer, *T. mega*, Dutton and Tod, and *T. karyozeukton*, Dutton and Todd, and to have the nucleus situated distinctly nearer the posterior end.[2] In these respects it seems to closely resemble *T. nelspruitense*, Laveran, from a Transvaal frog. It is readily distinguishable from *T. inopinatum*, Sergent.

The trypanosome of *Limnodynastes tasmaniensis* resembles in appearance the remarkable *T. mega* of Dutton and Todd, as figured by Laveran and Mesnil; as these authors consider that this species is merely a form of *T. rotatorium* and as our specimen stained so poorly as to make detailed examination impossible, it must also be provisionally placed

[1] Laveran and Mesnil, "Trypanosomes and Trypanosomiases," Engl. transl. by Nabarro, 1907, p. 465 etc.

[2] Lühe in Mense's "Handbuch der Tropenkrankheiten," III, 1906, p. 89 - 91; Laveran and Mesnil, *l.c.*, p. 465 – 476.

under the name of *T. rotatorium.* Its posterior end was very long and finely pointed; the nucleus appeared as a prominent faintly-stained area, and a little behind it the undulating membrane could be seen to take origin, indicating the proximity of the centrosome to the nucleus. The protoplasm stained a fairly deep blue and seemed somewhat granular; the undulating membrane, which was deeply folded, was only just discernible.

Measurements of the Trypanosomes in micromillimetres.

(Nos. 1, 2, broad form, from Harrisville frog; Nos. 3–8, narrow forms, from same frog; No. 9 trypanosome of *Limnodynastes tasmaniensis.*) Harrisville frog's red blood corpuscles, 17·8 μ × 8·9 μ; nucleus, 5·34 μ × 3·56 μ.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Posterior end to kinetonucleus	8 0	8·9	5·3	8 9	4·0	5 3	4 0	8·9	9 0?
Kineto. to edge of nucleus	1·8	2·2	3·5	1·8	2·6	3·5	2·2	1·8	3·0?
Nucleus length	3·5	3·5	2·2	1·8	1·8	1·8	1·3	1·8	2 5
Nucleus to anterior end	19·6	23 1	21·4	19·6	14·2	16·0	16·0	19 6	24·0
Free flagellum	26·7	19·6	7 0	19·6	9·3	9·0	15·0	17·8	4·5?
Total length	59 6	57·3	39·4	51·7	31 9	35·6	38·5	49 0	43·0
Total length without flagellum	32·9	37·7	32·0	32·1	22·6	26·0	23·5	31·2	38·5
Greatest width including undulating membrane	8·9	8·5	4·8	4·4	4·0	3·4	4·0	5·2	7·0
Breadth of undulating membrane	3 5	3·5	1·8	1·8	2·6	1·8	2·2	2·6	3·4

Dr. Bancroft recently informed us that he had found trypanosomes in the following frogs in Queensland:—*Hyla nasuta*, Gray, and *Hyla lesueurii*, Dum. and Bibr.

HÆMOGREGARINA (LANKESTERELLA) HYLÆ, n.sp.

(Figs. 11 - 22.)

The red blood corpuscles of the common "Green Tree-frog" of Australia, *Hyla caerulea*, White, appear to be very frequently parasitised by a haemoprotozoon belonging to the Haemogregarinidæ. This sporozoon has been detected in three out of five specimens of this species examined by us. Although we have sought for haematozoa in the allied "Golden Frog" *Hyla aurea*, Lesson (sixteen specimens) we have not yet succeeded in finding any. The infected frogs came from the Sydney district, but the species ranges over the whole of the warmer portions of Australia.

The parasites showed the typical features of a batrachian *Haemogregarina* (*Lankesterella*). They did not vary much in size, the length being about 0·009 to 0·011 mm., with a maximum breadth of 0·003 mm., though on one occasion a form having a breadth of 0·005 mm. was noticed. The parasites were generally much thinner varying from 0·0016 to 0·0025 mm. Many of the narrower forms were immature. The usual shape of the parasite in the red cell was that of an open crescent, its concavity most often facing the host-nucleus, but occasionally turned from it. In parasites which had escaped from their hosts, the two sides were however, almost alike. In the centre of the concavity there was often present a more or less extensive bulging. In no case did the parasite possess a tail.

The protoplasm of the parasite proper stained a pale bluish colour. It was usually studded with fine reddish granules. The nuclear band was often nearer one end than the other, and sometimes in these cases the part of the parasite beyond the nucleus was non-granular, while the rest of the parasite was distinctly granular. In a number of cases the characteristic reticulate nucleus was not dis-

cernible as such, but instead, opposite the centre of the concavity of the parasite, was grouped a number of purplish granules which at times extended beyond this area as scattered grains. A vacuole was often associated with the mass. In the heavily parasitised frog, unusual appearances were noticed which suggested either that these granules were not of the same nature as the nucleus proper, (our specimens were all Giemsa stained), or else that portion of the nuclear chromatin separated itself from the nucleus proper. The appearances were as follows:— The group of granules referred to seemed to emigrate into the bulge lying first of all close to the parasite proper, sometimes in a non-staining vacuolar-like space, and free in the bulge. In many of these cases, the true band-like nucleus itself could be distinctly recognised quite apart from the mass, and situated more towards one end of the parasite, the bulge being then a little to the other end. Further, in the same specimen, a number of rounded, comparatively large, purplish chromatic-like bodies were seen (one in each cell—once two in a cell) free in the protoplasm of the red cell, occasionally close to the bulge, but more often far removed from this and even to be seen opposite the convex border of the parasite. It was noted that in these cases, the bulge was slightly developed or absent. The protoplasm of the parasite proper seemed often sharply differentiated from this bulged area, and in some cases the outline of the body proper could be traced trasversing the bulge, distinctly following the regular curve of this side. There were, further, sometimes differences in staining reactions by Giemsa's method: the parasite itself staining a definite bluish tint, with or without granules, and the bulge being a paler blue or colourless and vacuolar like, or with a colourless centre, but a deeper blue periphery. In some free forms of the parasite which were seen, it is note-

worthy that the bulge was not noticeable. In the heavily infected frog, some mitosing red cells were met with.

It is difficult to know what the bulge and chromatic-like mass represent. It must be borne in mind that the specimens obtained were dry blood-films stained by Giemsa's method and that, at the time, we were unable to adopt the more exact methods for fixation or staining advocated by Minchin. The question of distortion from drying and the accentuation of size of chromatic structures by the stain must be taken into account. Allowing for these imperfections, however, it is obvious that the bulge exists, and that masses are often present in the parasite which resemble chromatin by Giemsa staining, and yet are sometimes distinct from the nucleus. We have seen these chromatin-like masses collecting opposite the bulge, passing into it, and finally grouping in it, and we have further seen free bodies suggesting that these masses finally escape from the bulge and wander into the host's protoplasm. Is the chromatin-like mass excreted through the bulged area? Is it really chromatic in nature and a device for the reduction in the amount of chromatin of the nucleus proper? These are points which we hope in the future to be able to resolve. It should be noted that these remarkable appearances associated with the bulging were noted in only one of the infected frogs, and in this specimen the infection of red cells by the parasites was very heavy.

The animal occupied various positions in the host cell, the more common situation being diagonal. Occasionally it lay across the host cell between the nucleus, which might or might not be displaced. Sometimes its position was between the nucleus and the side of the cell. In one instance it was located longitudinally between the nucleus and one end of the erythrocyte. Not infrequently the host nucleus was more or less displaced, but in no case was it

ejected from the red cell. The red cell itself was neither enlarged nor distorted as often happens in the case of reptilian erythrocytes when infested by haemogregarines.

Double infection was common in one of the films examined and even triple infection was seen. In all observed cases of double infection the two parasites were lying side by side either parallel to each other or forming a narrow open V. No schizogonic stages were met with. The films were taken from the heart blood and were stained by Giemsa. The type slide of this parasite for which the name *Haemogregarina (Lankesterella) hylae* is proposed, has been presented to the Trustees of the Australian Museum, Sydney, co-types being retained in the Bureau of Microbiology, Sydney.

The finding of the haemogregarine so commonly in *Hyla caerulea* but not in *H. aurea* calls for remark. The two frogs are commonly found together in swamps, but, while *H. aurea* is essentially a swamp inhabiting species, *H. caerulea* is very frequently arboreal in its habits. The occurrence of the haemogregarine in one of these often associated species and not in the other, suggests either that the infection by the protozoon is specific in character for the one frog or that its alternative host has access to *H. caerulea* and not to *H. aurea*, which latter view seems to us unlikely. The haemogregarines of certain frogs, *Rana trigrina* and *R. hexydactyla*, are stated by Patton[1] to be transmitted by a leech. The same probably holds good for the above described parasite.

In addition to haematozoa, we have examined frogs for intestinal and other protozoa. Though not in any sense blood parasites, yet we consider it worth while to record the results here :—

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[1] W. S. Patton, Parasitology, I, p. 319, 1908.

Myxobolus sp.

This sporozoon is met with at times in *Hyla aurea* in the Sydney district. It occurs in enormous numbers in the genital organs, the whole organ becoming converted into a swollen tube filled with a whitish fluid containing myriads of these parasites. Attention has already been called to the presence of these *Myxosporidia* in this host.[2] They have not been found in any of the other species examined.

Opalina sp.

This degenerate ciliate infusorian is comparatively common in the intestine of *Hyla aurea*, *H. caerulea*, *Limnodynastes peronii*, and *L. dorsalis*, in Sydney district. It has not been looked for in other frogs.

Nyctotherus sp.

This actively swimming ciliate infusorian is very common in the above mentioned four species locally. There is also a very large form present in *Hyla aurea* measuring 0·47 mm. by 0·324 mm. Whether this is a distinct species from the smaller and commoner form we cannot yet say.

Explanation of Diagram.

Fig. 1. Normal corpuscle of Harrisville Frog, for comparison with the Trypanosome.

Figs. 2 - 10. *Trypanosoma rotatorium?* showing pleomorphism.

Figs. 11 – 22. Erythrocytes of *Hyla caerulea* parasitised by *Haemogregarina hylae*.

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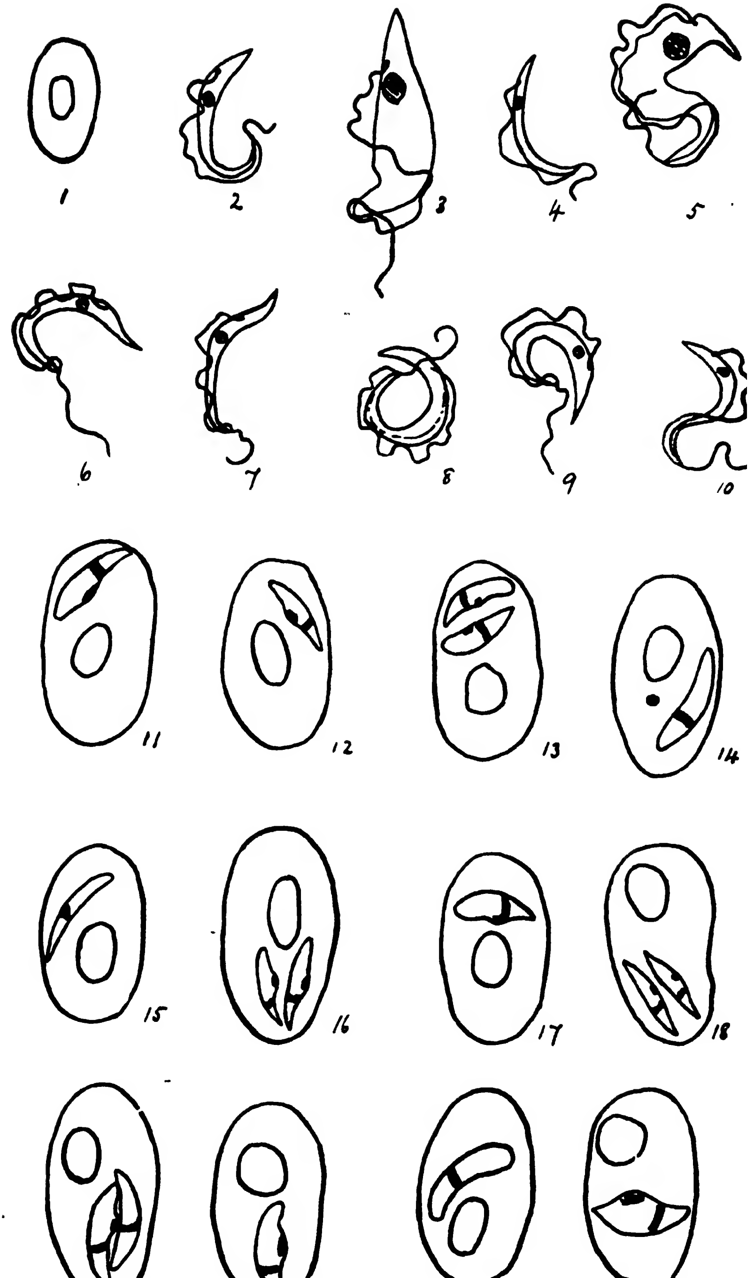
[2] A. W. Fletcher, *Proc. Austr. Assoc. Adv. Science*, I, 1887, 337. W. A. Haswell, *Proc. Linn. Soc. N. S. Wales*, V, 1890, p. 661. T. H. Johnston, This Journal, Vol. XLIII, 1909, p. xxviii.



T. H. J. del.

AN EXCURSION TO THE YOSEMITE (CALIFORNIA), OR STUDIES IN THE FORMATION OF ALPINE CIRQUES, "STEPS," AND VALLEY "TREADS."

By E. C. ANDREWS, B.A., Department of Mines, Sydney.

[*Read before the Royal Society of N. S. Wales, August 3, 1910.*]

TABLE OF CONTENTS.

Introduction.—In a previous report[1] the writer gave a general account of stream corrasion. Necessarily in such a report the subject could not be dealt with in detail. In the present note a more detailed account is given of the cirque, and the "steps" and "treads" of Alpine Valleys so as to make the statement of stream mechanics as simple as possible. From the principles here discussed the general case of valley overdeepening by ice may be easily understood. A special application of these principles is made to the case of both the Yosemite and the associated valleys in California. The scope of the following note is as follows:—

1. In the chapter on the psychological aspect of the problem, the main reasons are given for the great divergence of opinion on a problem which should have been easily amenable to proof. [Incidently it shows how difficult it must be to arrive at trustworthy conclusions concerning the origin of the earth, the condition of its central portions or even the origin of the Archæan Complex when the most acute geological intellects are unable to agree as to the activities involved in the production in recent geographical time of a mere surface form such as a typical Alpine cirque or lake basin.] The writer feels that the psychological factor has entered so largely into the question of glacial corrasion, that a clear statement of such factor is necessary, otherwise the young geologist may become hopelessly involved in dynamical difficulties. Such a student must take heed to free himself from the adverse suggestions received possibly in the lecture room, and he must test the soundness of his academic training by submitting the teaching there received to the rigorous test of field and laboratory observation. He must remember that one good observation leads nearer to truth than a whole lifetime of reasoning

[1] Andrews, E. C., "Corrasion by Gravity Streams," this Journal. XLIII, 1909, p. 204.

based upon unsound premises. He must not confuse the order of inorganic activities, neither must he confuse the operation of these activities during their most powerful and their decadent phases.

2. To place the matter clearly before the reader, a valley such as the Yosemite in California is considered, and the various steps in its formation are described. The conditions favouring local increase of glacial velocity are considered first, and this leads naturally to the consideration of certain fundamental conceptions in stream mechanics, such as the path of a stream particle, the strengths of streams as compared with the channel structures traversed, the kinetic energy of the stream, the energy available for corrasion, the location of maximum and minimum corrasion along a channel, the relation of channel form and stream strength upon declivities and in constrictions, the formation of roches moutonnées, and the profile of the cirque and "step." The relations of cirques to "steps" are also considered. Next the significance of glacial decadence is discussed. This introduces the subject of weathering at the cirque heads after the pronounced shrinkage in volume of the glacier. The effect of decrease in ice volume upon glacial flow in the cirque is also dwelt upon briefly.

The reader who desires to follow the historical side of the question of glacial corrasion may read with profit the works of Culver,[1] Fairchild,[2] and Hobbs.[3] In the work of Hobbs an interesting description of the glacial cycle is given. Reference may also be made here to a recent report by Tarr,[4] in which there is a distinct contribution to the

[1] Culver, G. E., "The erosive action of ice," Trans. Wis. Acad. Sci., 1895, pp. 339–366.

[2] Fairchild, H. Le Roy, "Ice Erosion Theory a fallacy," Bull. Geol. Soc. Am., xvi, 1905, pp. 13–74, plates; see also literature quoted.

[3] Hobbs, W. H., "The Cycle of Mountain Glaciation," Geog. Journ., xxxv. No. 3, pp. 268–284.

[4] Tarr, R. S., "The Yakutat Bay Region, Alaska," U. S. Geological Survey, Professional Paper 64, 1909.

philosophy of the subject of glacial corrasion. D. W. Johnson's recent paper on Hanging Valleys is instructive.[1]

The Psychological Factor in the History of the Glacial Controversy—Those who are familiar with Johnson's[2] simple statement concerning cirques and the "steps" and "treads" which interrupt the floors of Alpine valleys must have felt that he was on the point of making an important discovery, and they must also have felt that the correct explanation of the growth of such profiles would furnish the key to the solution of the problems presented by the peculiar profiles associated with them. Notwithstanding this[3] the cirque appears neither to have met with the attention it deserves in literature nor does it appear even to have been treated in the correct dynamical manner. The reason for this is mainly a psychological one. The keenest geological intellects appear to have approached the problem of cirque and "valley step" origins with the fixed idea that each is the product of an uninterrupted agency. Moreover, all attempts at a glacial explanation of the cirque form have been tacitly based upon the assumption that the activities which produced the cirque profiles are in as full operation to day as in recent times. Yet by such assumption it is possible that effect may have been mistaken for cause. No observer appears to have seriously considered the possibility, or probability, that the cirque has been formed by activities now practically inoperative, neither do they seem to have been aware of the fact that the base of the cirque of to day is partly filled with rock rubbish, while the head is being

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[1] Johnson, D. W.. "Hanging Valleys," Bull. Amer. Geog. Soc., XLI, 1909, pp. 665 - 683.

[2] W D. Johnson, "Profile of Maturity," Journ. Geol. Chicago, XII, 1904, pp. 569 - 578.

[3] See however :—(1) Davis, W. M., "Glacial Erosion in North Wales," Q.J.G.S., vol. LXV, 1909, pp. 281 - 350, and pl. xiv. (2) Hobbs, W, H., "Cycle of Mountain Glaciation," Geog. Journ., vol. xxxv, pp. 268 - 284. References to literature of cirques are supplied in this note.

modified by the establishment there of the atmospheric slope of repose in a wall from which the glacier has been withdrawn in great measure by diminution of volume.

It is matter now of common knowledge that, in recent geological time, glaciers were much larger than they are to day. Until recently it was thought that an Ice Age, (or period of Ice Flood as we may call it) was not at its height simultaneously at various centres, but that the greatest ice volumes were attained at different times at different localities. In brief, the idea of a cosmopolitan origin for an Ice Age does not appear to have been held by certain geologists. For example, until quite recently the idea was held that certain portions of the world were even now passing through their maximum phase of glaciation. Thus although it was apparent that England, Europe, North America, Asia, Australasia and New Zealand were all passing now through an Ice Drought phase, nevertheless it was thought that Greenland, Spitzbergen and Antarctica were passing through their maximum phase of glaciation at the present time. All the valuable observations in Spitzbergen and Greenland, howevèr, reveal the presence there to day of glaciers absolutely dwarfed as compared with those of a period which has only just disappeared. Everywhere are the evidences of deglaciated valleys, cirques, and associated profiles. Quite recently Professor David has shown for Antarctica that the recent Ice Sheet in that region was at one time very much thicker and more extensive than it is at present. In all countries the retreat of the last Ice Flood has been so recent that the very scratchings and polishings made by the ice are quite plain in almost every instance.

This being the case it is remarkable that such a fact has not been seīzed eagerly by geologists by reason of its mechanical significance. Knowing that diminution in

glacial volume, all other things being equal, is associated with a decrease in glacial velocity, and that the latter is associated with a geometrical decrease in corrasive strength, geologists should have perceived the fallacy of attempting an explanation of recent glacial motion along channels which have been formed by earlier and much more powerful ice masses. The whole question presents such a peculiar psychological problem, one so insidious, that it will be well, at this stage, to call attention to the various stumbling blocks in the way to the general acceptance of the conception of recent powerful corrasion by glaciers. In this way the younger generation of geologists may avoid the dynamical errors into which the fathers of the science fell half a centnry ago, and into which indeed some even of the present day leaders of the science have fallen, their judgment being suspended as a result of the influence of their environment.

When Ramsay announced his hypothesis of the formation of Alpine lake basins by glacial action, the geological world quickly divided itself into two camps, namely, those who believed, and those who did not believe, his doctrine. Those who believed had the evidence that certain peculiar and imposing land profiles were always and only found in regions of recent glaciation. Moreover they had the evidence that glaciers were capable of scratching, grooving and plucking (quarrying) rock masses over which they had passed. The unbelievers admitted the scratching and polishing action of ice; they admitted the removal of the waste sheet, and the formation of roches moutonnées and of some tarns by such action, but they saw nothing unusual in the land profiles around them, nothing to suggest anything but a slight or negligible modification of ordinary stream channel profiles. To them the profiles of deglaciated valleys were the "normal" types and such as could be

explained by ordinary stream processes. Whether they went to Norway, to Germany, to the Alps, to Spitzbergen, Canada, Greenland or the Himalaya they found similar profiles. This was to be expected, because all such localities have been intensely glaciated. And yet a single intelligent comparison of Norwegian or Alpine profiles with those of a warm temperate or tropical lowland or hilly region would have revealed to them the absolute dissimilarity, in general aspect, of the profiles of the contrasted regions. Thus Davis[1] describes his change of views on this subject after a visit to England, Norway, and the Swiss Alps. Dr. G. K. Gilbert in a letter to the writer, described his own case as follows: "I am also interested in a psychological point you mention. Your sensitiveness to the topographic peculiarities of southern New Zealand was due to previous training in non-glacial regions. I myself had a similar experience except that the sequence of events was inverse. My youth was passed and my early geologic studies were made in a glaciated region. When I afterward studied the mountains of the Great Basin where evidence of glaciation is not ordinarily seen, I was impressed with the topographic types because they differed from those that I was familiar with, and I was led to study the causes of their development and write an analysis of land sculpture by weathering and streams.[2] I think it quite possible that geologists who frame such curious arguments against the actuality of ice sculpture have never seen anything else, and are therefore not sensitive to the contrasts between the two types of sculpture." Numerous other cases might be cited where the "geological excursion" has helped to convince students of the efficiency of ice as a corrater.

Nevertheless while avoiding the serious error into which the non-glacialists had fallen through lack of comparative

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1 Glacial Erosion of North Wales, Q.J.G.S., vol lxv, 1909, p. 301.
2 Geology of the Henry Mountains, E. C. A.

studies, the leaders among the ranks of the glacialists fell into another error equally great by their non-appreciation of the fact that the present glaciers are only the weaker representatives of ice masses which, up till a very recent date, have occupied the same thalwegs and valleys. This error in turn was the result of environment. Whereas the error of the "non-glacialists" had arisen mainly through lack of observations in space, that of the "glacialists" arose through lack of appreciation of the sequence of events in stream action. They simply took glacial corrasion as they found it and assumed that, as now, so glaciers must always have worked. But by reason of such error they found themselves unable to answer the objections of the "non-glacialists." "How," asked the latter "is the idea of the overdeepening of valleys, the formation of lake and fiord basins, the facetting and removal of valley spurs by ice action to be reconciled with the knowledge that present-day glaciers appear least competent at just those spots where they should have been most energetic on the hypothesis of ice erosion." "How," said they, "can a glacier be said to have excavated a fiord basin when it may be seen overriding its moraine lying in the fiord basin; how be said to have made wide embayments in a valley when those very embayments are to day occupied by uncompacted moraine terraces; how be said to have quarried the mountain sides when they to day only scratch, abrade, or pass gently over a rock surface; how have cut the valley floor down for several thousands of feet when the roches moutonnées dotting that floor show abraded surfaces up-stream only, the downstream faces being frequently not even scratched; how have overdeepened cañons for thousands of feet when no moraines have been left there to evidence the destructive action; or how be said to have been such engines of destruction when they yield now only as flow by abundant crevassing, by shearing action of the

upper over the lower layers or by the almost infinitely slow rotation of large ice granules one upon the other?" The obvious answer to all these questions was first:—that all glaciers to day are passing through a decadent phase, that large as the Greenland, Spitzbergen, and Antarctic glaciers are as compared with those of the Alps or of temperate regions generally, nevertheless they are but the enfeebled representatives of recent Ice Floods; second, that the tortuous markings found along the floors and walls of the deglaciated valley portions[1] evidence the greater plasticity of the recent glaciers, and that therefore these departed Ice Floods must have possessed a mobility inconceivable from a mere study of present day glaciers.

There are several ways of arriving at this conclusion if one believes that glaciers are gravity streams; that the present glaciers are capable of erosion in even a slight degree, and that the recent Ice Floods lasted for some thousand of years. [All this, as one knows, is conceded by all geologists]. One could approach the subject from the standpoint of plasticity itself. For if the Ice Flood did excavate a channel adjusted to its needs, then any marked diminution in glacial volume would be accompanied by a great decrease in pressure, and a decided return thereby to a crystalline solid condition on the part of the glacier at the points where the greatest interruptions of channel base occur, with a corresponding sluggishness and alteration of form for the textural units of the glacier.

Or again, one could approach the subject from a consideration of the work accomplished by a glacier, the term work being used in its dynamical sense. Thus for a glacier to be enabled to corrade a point of its channel base it must, in common with any other gravity stream, carry its load

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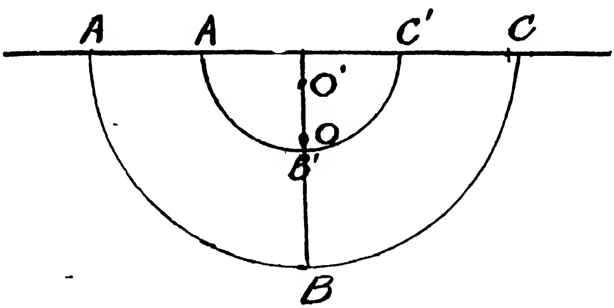
[1] Andrews, E. C., *Op. cit.*, pp. 264 – 268.

over the point under consideration.[1] Until such condition of affairs shall have arrived the vertical and lateral measures of transporting strength (and hence of corrasive strength) are not expended.[2] Thus to deepen the base of either a lake or fiord basin or of an over deepened valley generally, at any point, one may consider that all the mass of the glacial cross-section is gathered at its centre of gravity. Then stated in other terms one may say that, in order to be able to corrade either the base of the cross-section (or of the basin as a whole) the glacier must be able to transport the whole mass of the cross-section, or of the basin, if such mass be gathered at the centre of gravity of cross-section or basin, respectively. Thus at the height of the most recent Ice Flood, the glacier may be considered to have had the whole mass of a lake or fiord cross-section gathered at its centre of gravity, and to have carried it along thence without any difficulty. Now for the sake of simplicity, consider the cross-section of a lake basin below base level to be semi-circular, then its centre of gravity is three-eighths of the depth of the basin from the surface. (Fig. 1.)

Fig. 1.



Therefore a force which cannot move the whole weight of the mass of ice of the cross-section A B C, when that mass is gathered at O, the centre of gravity, cannot deepen

[1] Andrews, E. C., *Op. cit.*, pp. 219 – 221. [2] *Ibid.*, pp. 226 - 228.

the point B until the outlet has been lowered. Now if the mass of the glacier be reduced, say to a quarter of its former size, the mass so reduced can at this stage, only transport the mass of a small cross-section through its corresponding centre of gravity. That is, in our ideal case, the new cross-section will, from considerations of symmetry, be somewhat as shown by the profile A′B′C′, the vertical and longitudinal measures of glacial strength having shrunk considerably upon reduction in volume. But the centre of gravity in this case for the cross-section of the basin excavated below the associated base-levels will be at O′, a point vertically above O. That is the reduced glacier cannot corrade below the profile A′B′C′ and part of the ground moraine, or load, is deposited. The glacier, at this stage, is said to be overriding its moraine. But increase the volume again, and the centre of gravity of the cross-section possible below base level descends and the moraine is cleared away. Similarly one might consider the centre of gravity of any cross-section of a cutting curve in a glacial channel and consider the weight of the glacier in the cross-section as being gathered at the centre of gravity and being transported down stream. Then upon a reduction of glacial volume the centre of gravity is withdrawn to a greater distance from the old limits of the cutting curve, (that is the lateral measure of stream strength is diminished) and the old cutting curve at this stage becomes occupied by moraines which descend in terrace form from the cutting curve to the channel centre as the glacial diminution is continued.

Or again, the question might be approached from a consideration of kinetic energy.[1]

Nevertheless, although the same geologists would have been the first to admit the validity of these dynamical

[1] Andrews, E. C., "Corrasion of Gravity Streams," Appendix III.

principles had they never seen a glacier, yet they failed to appreciate them because of the adverse suggestion of the inertness of glaciers of to day. At every turn they were confronted with the effects of glacial decadence, but they did not perceive the dynamical significance of such decadence. It had been seen by them quite early in the discussion that the present glaciers of the temperate regions were insignificant, and it seemed thus quite natural to go for pilgrimages to the Alps, or to the Polar Regions, and there to find the clue to past ice action by studying the Ice Caps of such countries as Greenland and Spitzbergen. Then they fell into the serious error of mistaking the present Polar Ice Caps for Ice Floods, simply because such Ice Caps were much larger than the Alpine glaciers to which they had been accustomed. From the observations there made they commenced to construct a scheme whereby both recent glacial motion and corrasion might be explained, despite the glaring evidence to the contrary of glacial inactivity in the same regions. The error was perhaps natural, but disastrous the more so as their own observations, had proved that both the last Ice Flood and the present stage of diminished glacial volume were due to cosmopolitan causes. It was disastrous because the dynamical laws involved are unchangeable and any attempt to deny them is unscientific. The glaciers of the Polar regions are certainly large, but they are mere pigmies compared to the recent Ice Caps as revealed by the wealth of deglaciated valleys in the same regions. It was thus unsafe to draw detailed conclusions as to the past glacial motion by a mere study of the present Ice Caps. One might as well expect to understand the action of the recent glaciers by a consideration of large ice cubes in a laboratory.

An analogy borrowed from ordinary stream action may help us here, if the meaning is not already clear enough. It is well known from the studies of Hutton, Playfair,

Gilbert, Jukes, Davis and others, that ordinary river channels such as those of the Thames and the Amazon have been developed by their contained streams, and it has also been shown by Gilbert, that the form of the channel shows that it is the flood and not the normal stream which does the work of channel formation. Now all this is easily understood, because the action of both flood and normal water streams falls within the experience of every observer. But let it be supposed that certain cosmopolitan agencies had caused periodic and long continued floods, say once every 100 years. Then suppose some intellectual beings with ephemeral existences only to become interested in the origin of ordinary stream developed valleys. Not one of them had ever seen a flood, nor had there been any record of a flood since they had commenced scientific investigations. They would naturally be at a loss to account for the deep rock basins, the cutting curves and the general width of the channels, seeing that at these spots the normal streams appeared to be least active. After a time some one might draw attention to the huge heaps of débris among and through which the normal stream bubbled at one place and became dammed in another to form ponds. The idea of the existence of former floods would now be suggested and generally adopted. At this stage someone might be emboldened to announce a flood origin for the larger channel profiles, such as the rock basins and the main cutting curves, but this idea would be received with disfavor because no one had seen the action of a flood, and inasmuch as the water in the deep pools of the channel appeared to occupy the exact spots where the stream revealed its least competence, so would it seem utterly ridiculous to expect these spots to have been the sites of maximum energy simply as a result of increasing the stream volume. Of course such a conclusion would not be reached from a consideration of dynamical principles, but simply

because it agreed with the evidence of their senses. At this stage of the inquiry some one might propose that the question of a flood origin for the channels could be settled at once by an actual examination of the mighty streams of the Mississippi and the Amazon. The argument would be much as follows :—" The waters of the ordinary Amazon are much greater than the mightiest floods ever experienced along the Thames, therefore, if floods have done the work of forming the channels, then an examination of the mighty Amazon or Mississippi should settle the question." The explorers would then examine the normal flow of these giant streams; they would see the water winding lazily along the broad reaches and lying almost stagnant in places, and even along the more swiftly moving portions upstream they would see that the pebbles and boulders were not moved by the streams. Upon their return they would report that the flooded Thames could only move similarly to the low-level Thames, because the mighty Amazon moved in a similar way. Then the observers would become divided into two camps—first, those whose keen insight had shown them the presence of peculiar profiles apparently intimately related to the flood limits of the streams, but who nevertheless could not explain the mechanical difficulties, and second those who simply denied the hypothesis of channel formation by streams. And this would be an expectable consequence. Nevertheless their methods would be unscientific, because in the first place they would have failed to perceive the complex relation of the increase of stream velocity to its increase of corrasion, and in the second place they would have confused the normal Mississippi (or Amazon) with the same stream in flood, simply because the normal Mississippi (or Amazon) was of much greater volume than the Thames in flood. The latter error would be serious because it failed to convey the truth that the Thames in flood made its own channel; could the

Amazon stream volume have been turned along the Thames valley it would have powerfully corraded the channel bed and sides, because it would have found a channel which had been formed by a relatively weak stream only. On the other hand, mighty as the Amazon channel was, it had been adjusted to the strength of its own mightiest floods, therefore its normal stream could only play along that channel. The flood channel tolerated the diminished stream and furnished a disporting ground for it, but it was not moulded by it, but rather the normal stream had to adapt itself to the channel it occupied and lie stagnated here and anon tumble over a rocky ledge, and always exhibit its most pronounced inactivity just where the mighty floods had produced the maximum interruptions of channel base.

And this is similar to the attitude of some to day, to glacial action. An Ice Flood has never been seen; that stage has just gone, and the consequently diminished glaciers are adapting themselves to the details of contour of their channels. Here they lie stagnant, anon they yield by crevassing and sluggish flow, anon they avalanche from an upper to a lower glacier. In every case the maximum inactivity is observed at the maximum interruptions of channel base such as at huge fiord basins and cutting curves, that is, where the recent Ice Floods had worked most fiercely. Then men have gone to the Polar regions to study Ice Flood action, but it is simply the case of the normal Amazon and Thames again; the Polar regions are not passing through an Ice Flood stage at present, but they have just passed through such a stage, and the glaciers are now in a condition of diminished volume.

Still another deduction from these Polar and Alpine pilgrimages which has moved back the hands of the clock of geological progress, was that which was based on observations made on glacial motion. As all normal streams

tend to return to the static condition in basins and at other points of maximum interruption of channel base, so the reduced glaciers in turn of the Alps and the Polar Regions tend to return to the crystalline solid condition during the present stage of reduced ice volume, and they appear as crevassed and granular masses whose upper portions are constantly shorn over the lower ones. Because of the stagnation and incompetence thus evidenced, we are now seriously told that this is the motion peculiar to ice generally, whether in flood or in low level stages. This point of view had perhaps better be considered merely as a phase of glacial motion peculiar to decadent, not to corrasive stages.

But enough has here been brought forward to prove the importance of the psychological factor in the discussion on ice action—the suspension of judgment on matters scientific when opposed to the direct evidence of the senses. A summary of conclusions based on the mechanics of stream action has been given elsewhere by the writer.[1]

Topography of the Yosemite Locality.—*The formation of the cirque, the valley "step" and the interstep "tread."* In the present paper the floor of the Yosemite Valley of California is considered as a magnificent example of an aggraded "tread" of a valley "step," while the rough broken ledges which separate the Yosemite Valley proper from the Upper Merced Valleys are considered as a succession of "steps" or modified cirques.[2] Thus both the Nevada and the Vernal Falls are fine examples of valley "steps."

The peculiarities of the Yosemite topography are the width and flatness of the valley floor, the characteristic

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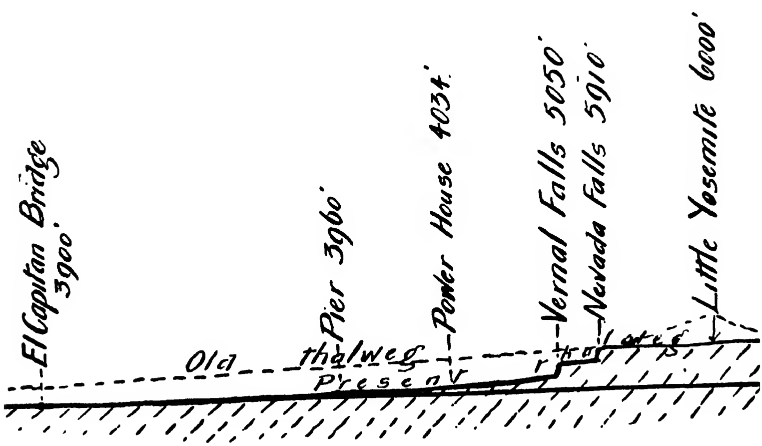
[1] Andrews, E C., "Corrasion by Gravity Streams," pp. 321 - 323.

[2] To F. E. Matthes, however, belongs the honour of having first appreciated the cirque-like appearance of the upper portion of the Yosemite Valley. Information communicated to writer by letter.

absence of talus or morainic material, the steepness and height of the valley walls, the ragged nature of the upper 1,200 or 1,500 feet of the same, the absence on this upper portion of the valley walls of glacial scratches or polish from Glacier Point down stream, the general parallelism of the walls themselves and the hanging nature of the tributary valleys. The accompanying figure is a representation of the thalweg of the valley from El Portal to the Little Yosemite as taken from Matthes' topographic map. Above in dotted lines is shown what appears to have been the position of the thalweg during the period immediately preceding the most recent Ice Age.

Fig. 2.

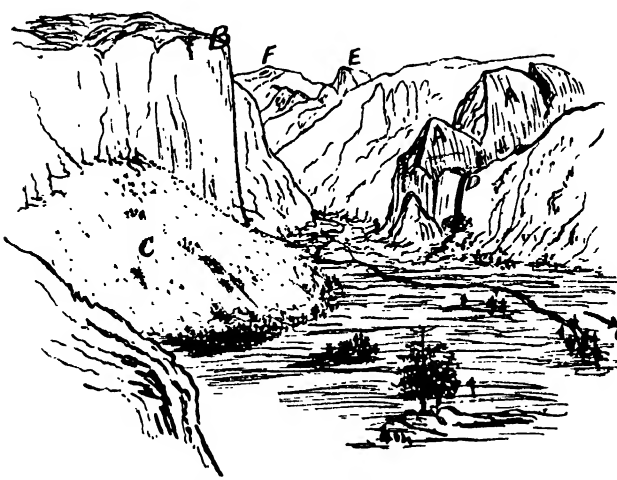


Present and recent thalwegs of the Yosemite. Horizontal and Vertical Scale, 1 inch = 8,000 feet.

It will be seen that the narrow floor of the Merced Valley ascends rapidly from El Portal until the meadow immediately down stream of El Capitan is reached. Here the meadow or flat which is about half-a-mile in width is entered upon, and through it the Merced stream winds in sluggish meanders. Upstream the flat floor suddenly ends and the thalwegs of the Tenaya and Merced rise in pro-

digious "steps" to the broad upper valley bottoms. The flat-floored valley of the Yosemite itself is about seven miles in length. and appears to be guarded by the two enormous portals of El Capitan and the Cathedral Rocks, which advance towards the centre of the valley and there form a decided constriction. Down the Cathedral Rocks the Bridal Veil stream may be seen flowing along a steep thalweg before precipitating itself into the main valley from a point about 800 feet above the Merced. The idea

Fig. 3 (*a*)



General appearance of Yosemite Valley taken near Inspiration Point.

A A—Huge Joint along which Bridal Veil stream has been formed. These strong joint planes are common and characteristic of Yosemite.

B—El Capitan, 3,000 feet above valley.

C—Talus near El Capitan.

D—Bridal Veil Falls.

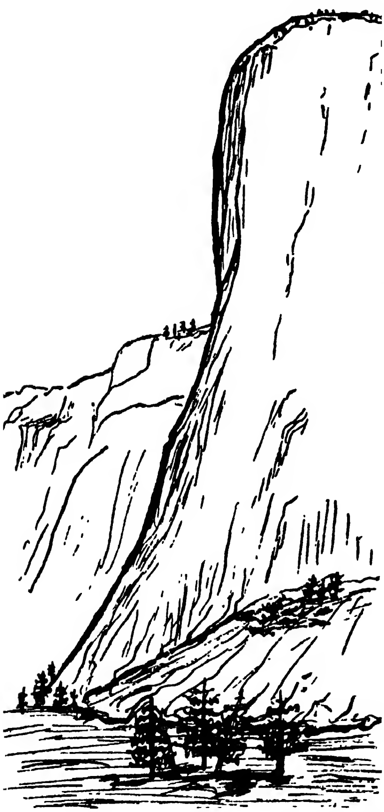
E—Half Dome, 5,000 feet above valley.

F—Clouds' Rest (9,980 feet) 6,000 feet above valley.

G—Direction of Inspiration Point.

is strongly suggested from the general appearance of the valley at this point, that the Bridal Veil stream grade at some previous period had extended without interruption in advance of its present position. In ascending the main valley above the constriction formed by El Capitan and the Cathedral Rocks, one finds oneself inside a remarkable valley whose steep and almost inaccessible walls rise from 3,000 to 4,000 feet above the flat floor. Yosemite Creek is seen flowing along a thalweg of moderate steepness and then plunging for 2,600 feet to join the sluggish stream below. (Fig. 4.)

Fig. 3 (*b*).



El Capitan.

Height of cliff above valley, 3,000 ft.
Height of dome „ 3,300 ft.

Some distance upstream the valley again contracts and the Tenaya Gorge actually becomes V-shaped in cross section. A rude sort of amphitheatre connects the Little Yosemite Valley with that of the Yosemite proper. Another peculiarity which attracts the attention is the well jointed granite in which the valley has been excavated. The whole igneous mass is thus cut up into a series of large parallelopipeds, which at times almost represent irregular and uncemented masonry. At frequent intervals also very large vertical and inclined

master joints occur. These joints are often quite wide and form veritable lines of weakness. In fact the peculiar slopes of the Eagle Peaks, the Cathedral Rocks (Fig. 3) and some other crags, appear to be due to removal of huge masses along such master joints. Turner has called attention to the influence of these joints in determining the form of the Yosemite.

Fig. 4.

Yosemite Valley and Falls from Glacier Point.

A B—Yosemite Falls, 2,600 ft. high
C—Glacier Point, 3,200 feet above valley.

It is evident to the observant that the main portions of the valley walls from Glacier Point down stream are due to sapping during some recent time, and that the marks of the latest Ice Flood (the one considered in these pages) did not reach Glacier Point by quite 1,200 or 1,500 feet. Inasmuch, however, as the flood mark exceeds the 7,500 feet contour under the Half Dome in the Merced while it does not reach the 6,000 feet contour under Glacier Point, it is evident that a great Ice Fall took place in the neighbourhood of the Half Dome and Liberty Cap during the later stages of the Ice Flood. It may be men-

tioned in passing, that there is strong reason for suspecting the existence of an earlier glacial flood which overrode the Half Dome, but its history is now so obscured that little is known concerning it other than that it appears to have been short lived as compared with the weaker but more enduring later phase.

It is almost certain from the appearance of the associated topography, that at some recent date the streams of the Upper Merced, the Tenaya, the Lower Merced, and the Bridal Veil valleys all joined each other with accordant grades. Along these older and moderately steep thalwegs a set of activities has been operating in such a manner as to have left the side valleys hung high above the main valley base. And looking from Glacier Point (Fig. 4) the result of such activities has been an enormous interruption of the recent valley bottom (as indicated also in Fig. 3 taken from a point near Inspiration Point) to the Little Yosemite and the Upper Tenaya valley floors.

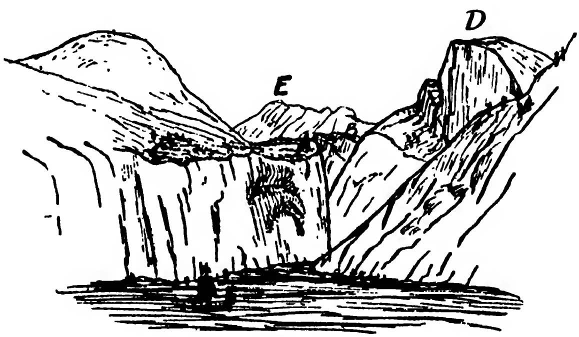
And not only for the Yosemite but also for the valleys generally of the High Sierras, one V-shaped valley has been excavated in the floor of another similarly shaped valley. In the case of the Yosemite it is the knobs and shoulders above the Royal Arches, the rock projections under the Half Dome as well as those under Clouds' Rest (Figs. 3 and 5) which indicate the remnants of the old floor below which the present mighty "steps" and "tread" have been made. A study of Figures 5 (*a*) and 5 (*b*) suggests that the glaciation of the Yosemite was imperfect, the trough-like appearance of matured glaciation is not present. The Upper Evolution and the Tuolumne Valleys afford additional examples of valley-in-valley structures, both upper and lower valley being practically spurless, flat-bottomed in places, dotted with basins or meadows and possessing a wealth of Hanging Valleys, with the lower valley floors

Fig. 5 (*a*).

Yosemite Valley from Clouds' Rest (6,000).

A—El Capitan (3,000). B—Washington Monument (2,000). C—Cathedral Rocks (2,600). D—Glacier Point (3,200). E—Half Dome (5,000). F—North Dome. G—Lower Merced Ranges. The truncated spur just downstream of Glacier Point evidences the youthful nature of the glaciation. All heights in feet above Yosemite Valley floor. This figure is a sketch only.

Fig. 5 (*b*).



Yosemite from the valley floor.

A B C—Old valley floor traces. D—Half Dome. E—Clouds' Rest

rising up to the higher ones by means of numerous large "steps" with or without rock basins on the "treads."

Furthermore the forms just described are those which are characteristic of stream action,[1] and in the valleys under consideration the only mountain streams known to exist which were large enough to have occupied such huge channels in their entirety were glaciers.

Before proceeding farther with the description of the Yosemite and associated valleys it will be advisable to discuss the principal methods by which streams corrade their channel bases and sides. Having done so it will be easy to make an application of such principles to the case of the valleys under consideration.

Some Principles of Glacial Mechanics.—A mass of any material, whether fluid or solid, is composed of various textural units and these same units may vary considerably according to the physical conditions obtaining at the time. Consider, for example, the granite bathylith out of which the Yosemite and Upper Merced Valleys have been excavated. The textural units of such a mass may consist of:

(1) The huge blocks of material bounded by the strong fault and joint planes occurring at frequent intervals.

(2) The parallelopipeds of rock, ranging in weight from a few hundredweights to 100 tons, determined by the frequent master joints of the region.

(3) The individual grains and crystals of the rock.

(4) The molecules of the granite itself.

It is evident that under certain conditions several sets of textural units may exist simultaneously. For instance, the great structural planes, the master joints, the individual grains and crystals, and the very molecules themselves may all form surfaces between which relative motion or

[1] Andrews, E. C., "Corrasion by Gravity Streams," p. 209 and reference.

flow may be taking place simultaneously. Of course, if pressure be applied to such a mass but no escape be present for the material so acted upon, then the problem is one of statics and not of dynamics. But if sufficient pressure be applied and an avenue of escape from the pressure be presented to the material then such a mass will move away from the zone of pressure along the lines of least resistance open to it. These principles are applicable to glaciers. Under pressure the textural units of the ice will lose their coherence and flow, or relative motion between these units, will be set up. When the pressure is the weight of the body itself the variable motion thus set up away from the zone of pressure is called stream flow and the lines of least resistance always taken are those of quickest descent. And this is true for all substances, whether solid or liquid. Of course in the case of liquids under ordinary conditions of pressure and temperature the effect of their own weights is to produce great relative movement between the textural units, but in the case of solids it is easily seen that the flowage caused by the weight of a body itself may possibly be of local occurrence only, and as opportunity offers such a mass will revert to its solid or inert conditions. As already pointed out by the writer[1] these peculiar conditions of inertness, partial rigidity, and plasticity, appear to exist simultaneously in any glacier of medium size. Thus on a declivity and in a decided constriction the flowage may be relatively perfect, whereas, in a broad valley, or at the bottom of a deep basin the motion may be relatively negligible,- while in a piedmont glacier or in a glacial "slack" generally the ice may appear to be quite inert. In brief, under the ordinary atmospheric cover only, one cannot expect ice to form a perfect stream. It may be mentioned in passing that during the recent Ice Age

[1] "Corrasion by Gravity Streams," pp. 212 and 273.

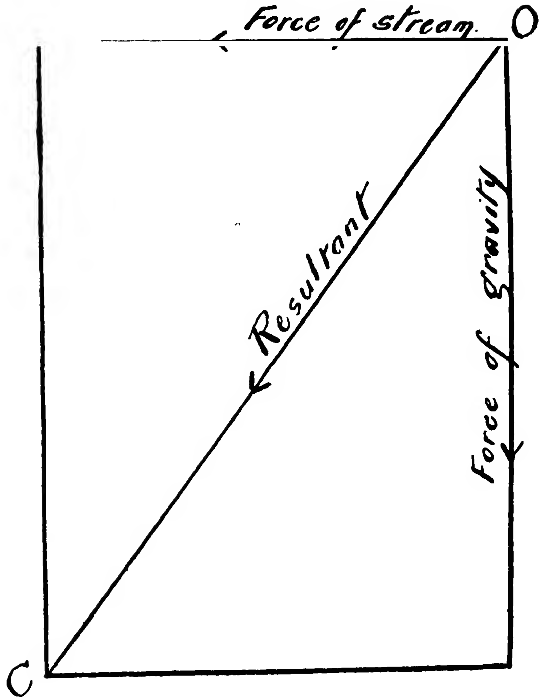
the glaciers were much more perfect examples of streams than they are at present, because during that period they excavated channels adjusted to their strength and were enabled to maintain their characteristics of flowage over all interruptions of channel base made by themselves. Similarly a river in drought is not a good example of a stream, as there are too many points at which static conditions practically obtain, whereas during the flood period there is no opportunity for a static condition to occur at any spot along the channel.

The evident aim of a stream is to move vertically, that is, in a direction perpendicular to the general plane of the earth's surface. Nevertheless the resistance of the earth's surface thus comes into play and by this means the stream is deflected at some angle to the vertical and takes the line of quickest descent. Thus the stream particles are constantly under the influence of a dual action, one that of the vertical force of gravity (practically constant at the earth's surface) tending to produce a motion of 16 feet during the first second of descent, another that of the force on the particles in the direction of motion at the point considered at any time. The latter imparts a variable and more or less horizontal velocity to the particles. To find the resultant force and direction in which the stream particles tend to move at this stage a parallelogram is constructed with sides of such lengths and position as to represent the amounts and directions of application of the two forces under consideration. The diagonal O C of the parallelogram as shown in the occompanying diagram shows the direction in which the stream tends to move.

Thus the stream tends at any point to move in a parabolic path.[1] In places where its movement is not cramped as over a ledge, its path is actually parabolic. The knowledge

Corrasion by Gravity Streams, pp. 216 and 323, 324.

Fig. 6.



of this peculiar motion of a stream is most important in any discussion of the locations of glacial striæ or polish or the relations between the possible quarrying and abrasive actions of a glacier. It is not that the stream does actually move in a parabolic path but merely that at any point along its course its tendency is so to move. The actual path determined depends either on the ability of the stream to corrade, or its tendency to aggrade its channel floor and sides, the curve in the first case being concave, and in the second case convex to the sky.

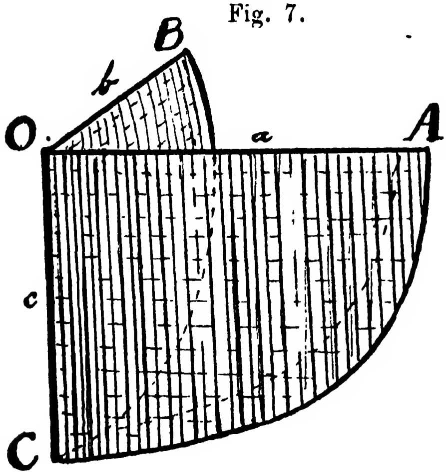
All streams, moreover, have their power of transportation raised as the sixth power of the velocity and their energy increased directly, both as the increase of the cross-section of the stream as as the third power of the velocity. But

this also implies the necessity for the stream strength to decrease in a similar ratio upon decrease in velocity. The latter is the main point which has been neglected hitherto in discussions upon glacial erosion.

From the foregoing it is evident that all streams follow the thalwegs of each other as opportunity offers. In the case where a younger stream is too large to be wholly contained in a channel of an older stream, then the thalweg, however, may be seen to be the location of maximum stream energy.

We are now in a position to discuss the energy of a stream in its relation to corrasion. Although the kinetic energy increases as the product both of the cube of the velocity and the increase of the cross-section, nevertheless there are the three directions to be considered along which this energy may be expended. These are the vertical, longitudinal and lateral directions, all perpendicular to each other and along each of which the energy is exerted in a certain proportion.

Fig. 7.



The three directions in which stream strength may be expended as corrasion.

Let O A, O B, O C, be three axes, all perpendicular to each other. Let O A be designated a, O B as b, and O C as c, then any stream expends a certain proportion of its kinetic energy along each of these three axes, and until such time as it is incapable of transporting that portion of the stream and its con-

tained load which overlies any particular spot on its channel base, the stream must cut vertically into its channel base, because it is a fact of observation that earth material which is dragged across earth structures will corrade the same, especially when the material of the stream load is harder than the structure it traverses. In short until such time the length O C will increase. Similarly while the stream is strong enough to carry its load past a point on its channel sides, so long will the length *b* grow along the axis O B. In other words the cutting curve will extend until the stream becomes unable to freely sweep the channel sides with stream débris. Similar reasoning may be extended to the case of the longitudinal axis.

Having made this point clear, it will be interesting to note the significance of the increase in volume of a stream as regards its ability to corrade. The laws of mechanics show that the kinetic energy of a stream apparently increases directly as the product of the third power of the velocity and the increase of the cross-section.[1]

Let us suppose that a basin has been formed in the chanel base by the stream. Upon the increase of velocity, all other things being equal, the new basin formed will be similar in shape to that excavated under the less energetic conditions, the ratios of the lateral, vertical and longitudinal measures of stream strength being the same as during the less energetic conditions, and the relative sizes of the basins being those of the approximate ratios of the two kinetic energies. From this knowledge the lateral, vertical and longitudinal increases in stream strength could be estimated. By increasing the depth and velocity of the stream without widening of the channel, the corrasion works in the direction of flattening the channel base, and in the production of steep vertical channel walls by

[1] Corrasion by Gravity Streams, Appendix III.

sapping action. In other words, the more pronounced the constriction of the channel the more pronounced will be the basin depths, produced by vertical corrasion. Similarly the basin depth has a direct relation to the general depth of the channel. The floor of the basin also becomes flatter in such cases, because of the inability of the stream to completely develop its lateral axis of corrasion[1] for the same reason. Upon a declivity the stream velocity is greatly increased and the structures of the channel base are easily removed. This interesting case is discussed later.

Methods of Stream Corrasion.—(a) *Relative strength of streams and rock structures.*—The walls of the Yosemite Valley or the allied San Joaquin Valley present the appearance of a well-jointed rock mass, the strength of the structure not being very great when opposed to the action of a force moving along a declivity. Figure 8 represents the Yosemite structures approximately. To remove a block such as that represented by X Y Z in figure 8, very little more than the power necessary to lift it is needed to dislodge the block from the ledge. This relative weakness of the granites of the Yosemite when acted upon by a downstream force is very pronounced.' This feature will receive fuller attention when the origin of roches moutonnées is discussed. It will be seen however that a stream of enormous volume such as the Yosemite Glacier of recent time would be able to drag huge rock blocks from their unstable anchorages on the channel declivities with the greatest ease, little energy being required for the dislodgement of the blocks beyond that necessary for their transportation, the jointing of the rocks being so perfect.

[1] This is the explanation of the deep fiord basins of Norway, New Zealand and Alaska. The preglacial valleys were very deep and narrow and had rapid descents to sea level. The vertical component of glacial strength was developed in these regions at the expense of the lateral component during the youthful stage of ice erosion, hence deep and flattish floored basins were formed.

Fig. 8.

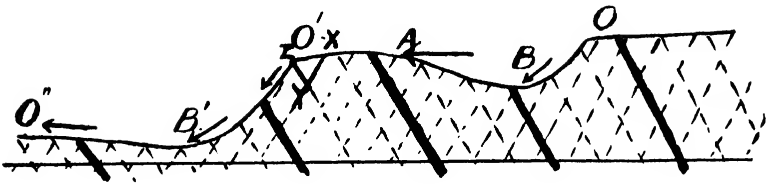


Diagram showing common granitic types of structure, whereby declivities are easily removed by strong stream action.

The peculiar relations existing between streams and strengths of channel structures appear to have been overlooked, otherwise there would never have been the long and fruitless discussions concerning the ability of glaciers to corrade and abrade. Even so late as 1909, one finds statements such as the following concerning ice mechanics, in the works of an eminent mining authority.[1]

"An examination of our modern glaciers shows us that a considerable thickness of ice seems incapable of abrading or modifying to any extent the surface over which it glides, even when carrying a load of rock fragments locked in its under-surface. . . . it is obvious that it would require a thickness of 3·500 feet of ice to exert a pressure above the ultimate breaking-strength of the schists.

"None of the existing glaciers in New Zealand are capable of excavating their beds, and it is doubtful if any in Europe or America are competent to do so. . . . . It is equally certain that ice can only excavate its bed when the pressure of its mass exceeds the ultimate crushing strength of the bed rock."

It will be seen that Mr. Park's difficulty lies in the fact that he is not here discriminating between the erosive values of recent flood and present drought glaciers acting along the same channel. The present inactivity of glaciers in New Zealand is not due to the fact that they are unable

[1] Park, James, "The Geology of the Queenstown Subdivision," New Zealand Geological Survey, Bull. No. 7, New Series, pp. 35 - 39.

to crush the rock structures of their channels, but that they are the much diminished representatives of glaciers acting along certain channels, which latter have been excavated by the former and larger glaciers. A stream abrades not so much by the action of its own mass as by the action of its load upon the channel structures. For corrasion, the strength of the stream needs not to exceed the ultimate crushing strength of the rock, although this phase is an important one.[1] What the stream does need, however, for purposes of quarrying and abrasion, is ability to accomplish one or all of the following processes (1) to lift out and transport large rock masses from their resting places, (2) to break rock masses across the joint faces (3) to overcome the coherence of the cementing material, (4) to sandpaper the rock face itself.

Action on lee seites and stoss seites of obstacles.—Consider the action of a stream [of ice or water] on a thalweg such as O O′ O″ (Fig. 8). A represents a local reversal of grade, and B and B′ represent basins at the feet of declivities or interruptions of the channel base. Now, because the streams are due to the force of gravity, the passage of the point A by the stream results in a net loss, while the passage of the face O′ B′ results in a net gain to the stream power. It is evident also that as the stream descends the slope O′ B′ its velocity increases, and hence its kinetic energy rises in a high geometrical ratio. Nevertheless because of this rapidly increasing velocity the proportion of the kinetic energy expended as corrasion rapidly diminishes. This is evident at once from a consideration of the path of a particle.

The next point for consideration is the amount of kinetic energy available for corrasion along various points on the thalweg. It is evident at once from a consideration of the

[1] "Corrasion by Gravity Streams," pp. 222, 223.

path of a particle that the maximum percentage of stream energy is expended at the points where the plane of the thalweg most opposes the motion of the stream, that is where the planes of thalweg and descending stream are inclined at the least angle to each other.

Thus in figure 8 the greatest percentage of the stream strength expended as corrasion will be at B, A and B′, because here the planes of thalweg and stream are inclined together at less angles than at any other points along the thalweg. For the same reason the least percentage of stream strength expended as corrasion occurs along the slopes O B and O′ B′ because at these points the planes of thalweg and stream tend to parallelism. The points needing consideration are the relative values of corrasion at the points A and B. During its descent of the slope O′ B′ the stream has been increasing rapidly in kinetic energy, while at the same time at A it has been robbed of a great portion of its energy in the formation of the basin B A. Therefore at the point B′ where the plane of the thalweg opposes the motion of the stream, the actual amount of corrasive strength exerted far exceeds that exerted at the point A. The action at B′ is to produce a basin or to over-deepen its channel so as to produce a decided interruption of the channel base because the energy expended at this spot far exceeds the energy expended as corrasion at any other point along the thalweg. A strong sapping action is thus set up at B′ which causes the declivity O′ B′ to assume the atmospheric slope of repose, but this slope in turn is completely modified by the action of the stream in passing down the slope O′ B′.

It will be advisable to discuss this action a little more in detail as the former "paradox of glacial erosion" was due (1) to the failure to grasp the tendency of a stream to parabolic motion, and (2) to the failure to appreciate the

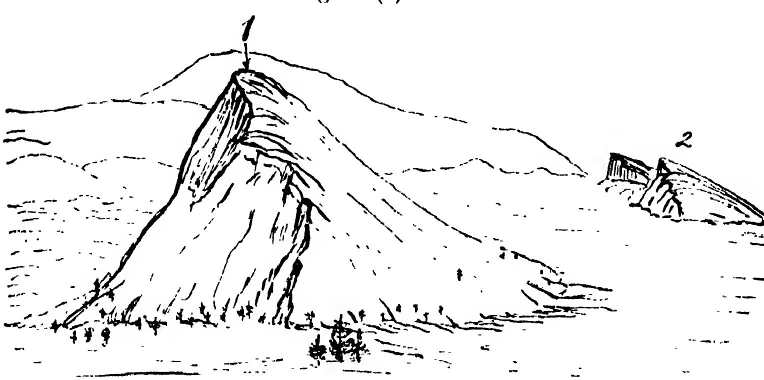
significance of a waning of glacial volume. Fig. 9 (*a*) represents a roche moutonnée form known as the Lambert Dome in the Tuolumne Valley above Yosemite. The rock is about 700 feet above the floor of the valley on which it lies. Fig. 9 (*b*) represents another roche moutonnée in the Tuolumne named Fairview Dome and about 1,400 feet high.

It will be noted that the stoss seite of the Lambert Dome is smoothed and rounded, while the lee seite on the down stream aspect of the dome is rough, jagged, and steep in character, and evidences little or no abrasion on its face. By the geologists who doubt the ability of glaciers to pro-

Fig. 9 (*a*).

Lambert Dome in Tuolumne Valley near Yosemite.

Fig. 9 (*b*).

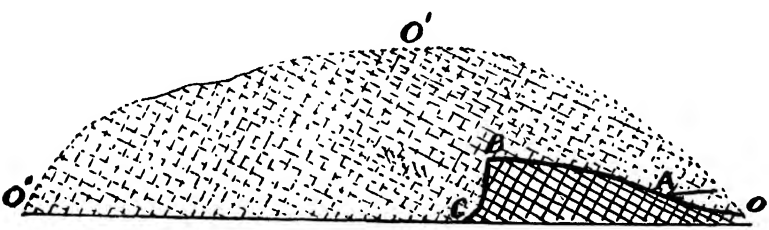


1. Fairview Dome, 1,400 feet high. 2. Lambert Dome, 700 ft. in Tuolumne Meadows.

foundly modify their channel profiles, such a form would be considered as direct evidence of the ineffiiciency of ice as a corrader. The rounded back of the roche moutonnée, according to them, evidences the abrasive action of ice, while the rough and jagged down stream aspect marks the original preglacial contour of the rock, and hence the failure of the glacier to strongly erode the channel forms.

But if this were really so, then glacial motion would be strong at some points where the planes of the thalweg and the stream were opposed and negligible, at others on the down stream aspect, where a similar opposition of the general planes of thalweg and stream exists a mechanical impossibility. Consider for example the accompanying figure (Fig. 10) illustrating the structure of a roche moutonnée.

Fig. 10.



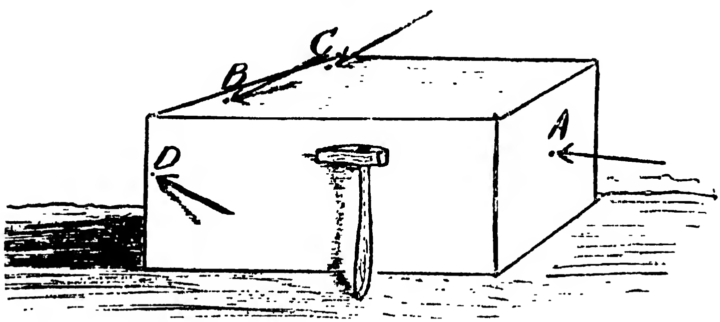
Illustrating formation of roche moutonnée.

Any pressure of the glacier at A is tending to crowd the structures together and compress them and corrasion here is accomplished mostly by sand-papering action with minor fracture of rock blocks. In this case abrasive action vastly predominates. On the other hand the passage of the glacier over the lip B of the roche moutonnée is accompanied by heavy quarrying because there is no support to the rock mass down stream of the profile B C, and the glacier can therefore easily pluck or quarry the blocks from the face B C. Moreover, in the cases of those roche moutonnée forms which form the whole floor of the channel—the point

C being much lower than A—the descent of the profile B C is attended by rapid increase of stream strength, and thus sapping becomes a most important factor in the production of B C.

Again the lee seite of a roche moutonnée must suffer less from abrasion in proportion as its slope is increased, until in the extreme case when the profile B C is vertical, the abrading action of the glacier vanishes, and corrasion is at a maximum by sapping processes. This is so because of the tendency of a stream to parabolic motion. A homely illustration may be borrowed from the ordinary methods of the petrologist. In the accompanying figure (Fig. 11) a

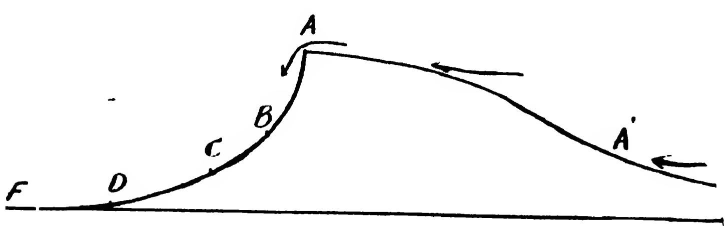
Fig. 11.



block, say of granite, is represented, from which it is desired to secure specimens. Will the collector steadily hammer at a point such as A so as to secure the best results, or will he strike in directions such as those indicated by the arrows B C D? By hammering at A he will simply compress the granite structures, unless indeed he possess enough force to smash the block clean through from A to D or B. If he strikes long and hard enough at the end A he will produce an abraded surface in the direction A B. On the other hand by equally heavy blows delivered at B C and D, he will cause a relatively rapid recession of the face, because instead of compressing the structures at

these points he is working in the direction in which the structures are unsupported, that is along the lines of least resistance. Nevertheless in proportion to the steepness of the face C B D will the abrading action of the hammer be negligible. That is if the face opposite to A be relatively flat, then his blows are often registered as abrasions, so long as he always strikes in the quadrant A C D as towards D, and not as from D to A, while if the face C B D be vertical no abrasions are produced. The analogy may be extended to ice action. The glaciers of the recent Ice Age even were not strong enough to smash a large moutonnée form (such as Lambert Dome) clean through from stoss to lee seite, they therefore compressed the structures on the stoss seite and abraded them mainly by reflection of movement. On the other hand they quarried the lee seite with relative ease by the breaking and transportation of blocks in the direction of least resistance or that of no support. In proportion as the smashing action of a glacier was developed, [in other words the stronger the glacier] so was the stoss seite plucked and then rounded while the lee seite remained jagged and unpolished. Even without knowing the direction of the associated glacial striæ, a student could instantly tell the direction of glacial flow by the peculiar ice markings on the lee seite of a moutonnée. For example in a moutonnée with a lee seite profile as in figure 12, the

Fig. 12.

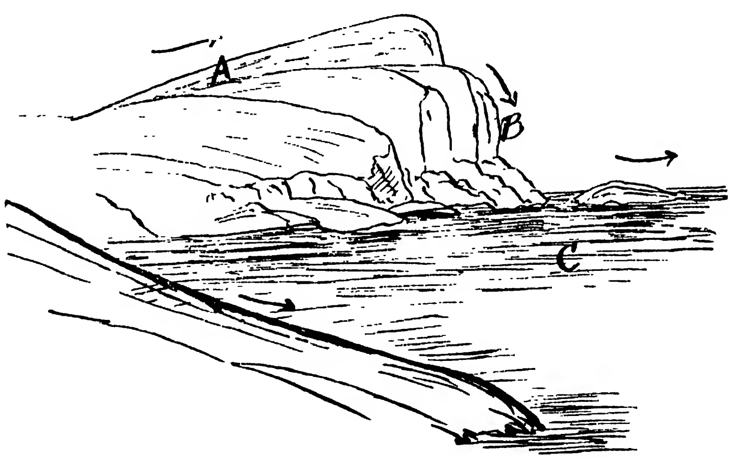


profile A B would evidence no polishing action by ice, the profile B C some polishing action, C D distinct polishing

action, and D F would evidence abrasive action almost as pronounced as the stoss seite.

To return to figure 10, B C does not mark the preglacial profile of the roche moutonnée ; most probably the original profile was somewhat as the dotted line O O′ O″ in the figure the face B C evidencing a long recession as from O″ to C. Nor is this purely deductive, it is based partly on observation, and partly on mechanical principles suggested by analogies taken both from comparative stream studies and from the ordinary operation of mechanical laws. Fig. 13 is a good example of the roches moutonnées found in the San Joaquin Valley.

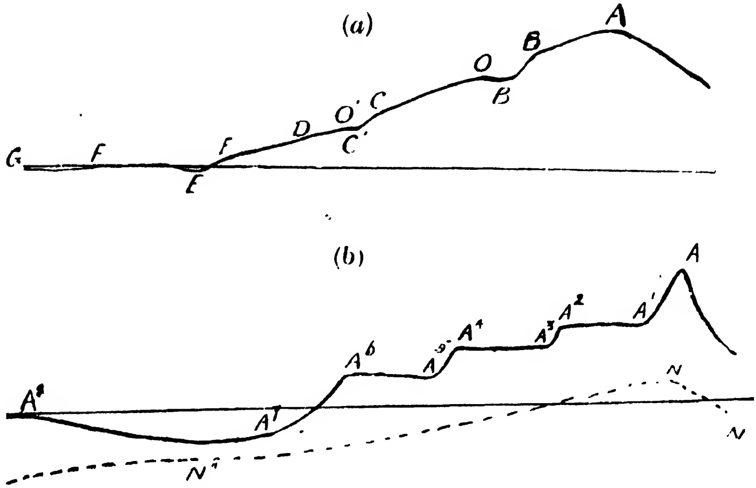
Fig. 13.



Roche moutonneé in San Joaquin Valley near Yosemite. A—Abraded stoss seite. B—Quarried lee seite. C—Rock basin.

Valley overdeepening.—Let A B C D E [Fig. 14(*a*)] represent a preglacial thalweg where A marks a divide, A D marks a pronounced declivity, and D E a very gentle slope. Let the channel between the points E D represent a deep constriction, and let the channel be also constricted at the points B and C, but less distinctly than along the portion E D of the valley.

Fig. 14 (*a*) and (*b*).



Formation of "steps," "treads," and cirques on a steep thalweg (declivity). (*a*) Preglacial thalweg. (*b*) A $A^1 - A^8$ Youthful glacial thalweg. N N′ N″ Matured glacial thalweg.

Now the velocity of the preglacial stream either had a uniform velocity or it had not. If the former, then the channel base was uninterrupted when all other things were equal, but if the latter, then the channel base was interrupted and the interruptions were proportioned to the strength of the stream. But channel constrictions imply increased velocity, therefore reduced grades (or channel base interruptions) will occur at the points B, C, D and E. This is of course on the assumption that homogeneous structures are being acted upon. In nature rocks are never quite homogeneous, and the differential strengths of the structures acted upon causes the incising stream to excavate a basin at one place and occupy a declivity at another place. In nature the interruption of grade would occur a little down stream of the constriction, that is, at the point where the softer rock bar was most opposed to the direction of the stream.

Imagine now an immense glacier to occupy the greater portion of the preglacial valley cross-section. If the valley be constricted at B and C and along D E, then the glacial velocity is increased at B and C, and along the whole distance D E.

There are now several points to be borne in mind in discussing the action of a large ice stream upon the channel whose bed is indicated by A B C D E.

(1) In descending the steep slope A E the glacier receives great increase in velocity generally.

(2) At the points B and C and along the whole length D E also, the glacial velocity is locally increased.

The kinetic energy of the stream therefore rises in a high degree and strong corrasion of the general channel base A E ensues, nevertheless, because the greatest resistance to the stream motion is experienced at the points B′, C′, and E′, the greatest percentage of stream energy which is converted into corrasion occurs at these points. Therefore the basins E′, C′, and B′ are deepened and broadened and lengthened until the lateral, vertical and longitudinal measures of strength of the new and powerful ice stream are altogether expended. An important point may be mentioned at this stage of the enquiry. Glacial action immediately down stream of the point E tends to compress the structures, because they lie below the temporary base level F G. Corrasion will therefore take on the form of abrasion mainly at this locality, quarrying action being possible only in the cases of large ice streams. It is the analogy with the geologist who hammers the centre of a rock mass instead of striking at the unsupported edges.

But in the cases of the basins C′ and B′ the action is dual. At the bottom of the basin the stream action is compressive and corrasion works mainly by abrasion to produce a rock

bound cavity, but in descending those portions of the declivities B B′ and C C′ which lie above O and O′ the ice gains considerably in strength, there is no support to the rock structures owing to the parabolic tendency of the glacial motion and blocks are easily detached from the rock face. Therefore recession of the declivity at various points ensues, and this recession takes place rapidly but with varying speeds.

"Steps" will therefore be formed by the recession of the profiles B B′, C C′ and of E. "Treads," are formed by the recession of the steps and a "thalweg" such as that illustrated in Fig. 14 (*b*) is formed at an early stage. An important point is here disclosed. It has been shown that in a deep constricted valley a large glacier during its youthful attack will form a deep and flattish floored basin as well as very steep channel walls. This is because of the inability of the youthful glacial attack to completely expend its lateral measure of corrasive strength. Because of this failure to increase the channel width rapidly the great depth and relative speed of the glacier is maintained, and this implies a relatively large vertical measure of corrasive strength. In the case of the recession of a "step" on a steep channel slope however, the abrasive force of the glacier at the foot of the "step" is very great, and therefore tends to the formation of basins at such points. But on the other hand the "step" recession is relatively rapid, and before the glacier has had time to excavate a deep basin on the "tread" the "step" has receded, because of the ease with which the structures forming the declivity are broken up on the unsupported aspect of the "step." By this rapid recession of the "step," the channel cross-section as rapidly increases and this implies a corresponding decrease of glacial velocity, with proportionate decrease of glacial strength. Therefore the "treads" of "steps"

may be expected to carry basins of but relatively slight depth. If the "step" recession be very pronounced and very rapid, the "tread" may not even possess a basin, its general profile being that of a gentle slope from "step" to "step." To return to the recession of the "step" at B in Fig. 14 (*a*). It will be carried back right into the divide at A. Nevertheless the "step" at A (the glacial divide) will differ in some important points from the "steps" at D and C. In the case of the latter the sapping action of the heavy glacial motion is very pronounced, and with this must be combined the quarrying action of the glacier as it descends the whole of the profiles C C′, E E′. This results in the wholesale smashing up of the structures forming these profiles, and in these incipient or recessional stages, the most youthful forms of glacial corrasion may be expected, such as V-shaped rectangular or irregularly-shaped cross-sections, there being but little opportunity for the development of symmetrical forms.

But in the case of the cirque proper, which has been developed at or very close to a glacial divide, the action is such as to produce a very different profile to that of the typical "step." We have seen that the typical cirque commences as a small "step" which by recession passes into the typical cirque at the glacial divide. Such action may occur along all the tributaries as well as along the main glacial valley itself; but in each case the action is similar. In the case of the main valley one would expect to ascend the thalweg by means of a series of "steps" and "treads," the highest tread ending in a cirque instead of an ordinary valley "step." In the case of a tributary valley one would rise up to it from the main valley by means of a "step," thence its floor would ascend in much the same fashion as that of the main valley. Thus one would expect to see tributary cirques discharging into the

main valley heads and cirques over ledges or "steps" each representing a recession along a tiny thalweg at the glacial gathering ground. It now remains to be seen by what activities the typical cirque obtains its peculiar profiles. In the first place it will be evident to students of dynamics that the "tread" of the valley which forms the lower portion of the cirque will be flat in proportion to the volume of the glacier which has caused the "step" recession, and also that the "step" which is formed by the development of the "tread" will be of great height in proportion to the steepness of the thalweg along which the recession has taken place. That is, all other things being equal, a cirque should be deep in proportion both to the volume of the glacier and to the steepness of the declivity (thalweg) along which it has been developed by recession. In regions of heavy snowfall therefore and in steep Alpine countries one must expect the grandest development of the cirque form. And this is evident from what has been adduced in the present discussion on stream mechanics, no matter how insignificant the initial "step" and "tread" may have been. Another point into which we cannot enter fully here, because of lack of space, is that every stream tends to form a channel of such shape and size as to satisfy the demands of the lateral and vertical measures of its strength. That is to say, under similar conditions, streams even of different material will form similar profiles, nevertheless the more voluminous stream will form profiles altogether larger than those of the stream of smaller volume. So long as the thalweg is steep and the channel deep and narrow, the vertical factor of corrasion is dominant; so long as the channel walls are deep and strong so long will the lateral factor of corrasion be cramped in its movements because of the compression of the structures (by the overlying rock weight) which opposes the lateral cutting action; so long as a stream is of great relative depth, so long will the

vertical measure of strength be great; so soon as a stream becomes of negligible depth, so soon does it lose its corrasive power either in a vertical or lateral direction. From a consideration of these various points it may be shewn that the tendency of a stream is to develop a flattish floor to its channel, the width of such floor bearing a definite relation to the volume and velocity of the stream. That is to say a valley floor formed by a glacier of a definite size is not adjusted to the needs of any other glacier of different volume then the whole channel will be widened symmetrically and the old profiles will be removed altogether. If we reduce the volume, the new glacier will not be able to utilise the old floor in its entirety, but will proceed first to fill up the greater irregularities of channel form and then to excavate a narrower but similarly shaped channel along the floor of that which had been determined by the greater volume.

Similarly during this stage smaller "steps" and smaller cirques will be developed within the older and larger examples. It is evident that a large glacier must produce a much greater channel than that produced by a stream of lesser volume, even if of much greater mobility. A moment's reflection would thus be sufficient to convince those who deny the efficacy of ice as a rock corrader, that the peculiar floors of hanging valleys (of Alpine Regions) of cirques, and the "treads" of "steps" could not be used as channel floors in their entirety by the ordinary water streams of those regions. The study of the mechanics of of stream action shows that such streams are competent only to excavate notches in such floors during the initial stages of attack. It would be a mechanical impossibility for any water stream in California to utilise the whole of the lower 2,000 feet of the Yosemite as a channel, and any appeal to ordinary stream action as having formed the

peculiar profiles of typical Alpine valley floors and walls is futile, and would show that the argument had been based on ignorance of stream mechanics. The very fact that the present water streams now occupy tiny canons only, which have been excavated in the flat floors of the old channel, shows first, that the large channel was formed by some other agent much more voluminous than the present ordinary streams which drain these peculiar floors, and second that the water stream has only just commenced action along such floors.

This slight digression was necessary to make clear to the student that glaciers form large channels as compared with those formed by smaller water streams, and that under certain conditions one must expect to find cirques thousands of feet in depth, and also of great length and width. It is simply a question of the combination of glacial volume, of the steepness of the old channel floor, and of the width and depth of the old stream formed valley itself.

To return to the consideration of the formation of the cirque. In the first place since the typical cirque is only developed at a glacial divide (and not some distance down stream nor under an ice-swept col) it is clear that the corrasive action of the ice or snow at its lip is a negligible quantity. In the second place it is clear that the cirque is a considerable gathering ground itself. Thirdly, the volume of the ice will increase towards the base of the cirque and therefore its mobility will be much increased. This implies a great increase in corrasive power. Fourthly, since the "step" (or cirque) and "tread" have been formed by the ice stream during a period of heavy volume, then the principles of stream mechanics show that such ice stream must have been in a state of compression in the cirque so long as those conditions of heavy volume obtained. The ice stream must have maintained a continuous surface over

the whole channel floor irregularities. That is, there could have been no bergschrund or sympathetically curving crevasses but rather a slight depression in the central portion of the cirque glacier and a slight heaping up at the sides near the base of the cirque. For a moment's reflection will suffice to show that a glacier which possesses a bergschrund and is much crevassed has not formed its channel irregularities, but has rather been moulded to them so as to have been put into a state of tension with consequent destruction of stream characteristics.

Fifthly, the least percentage of ice action which is expended as corrasion is that accomplished while descending the heavy slope of the cirque, while the greatest occurs at the foot of the cirque or that spot where the plane of the channel floor is most opposed to the motion of the descending ice.

We have then a complex action in a cirque. There is relatively heavy corrasion at the base of the cirque. The action there however is mostly abrasive, because of the tendency to compress the structures instead of quarrying them at this point. The base of the cirque will be lowered until the vertical measure of strength has been expended. This results in heavy sapping which tends to induce the atmospheric slope of repose in the cirque walls. This sapping action is however only a partial factor in the formation of the cirque walls, because of the corrasive action of the ice in descending the cirque slopes. The reasoning here should be followed closely, because it is necessary to clearly grasp the conditions obtaining in this portion of the cirque. Firstly, then because the cirque is situated on the glacial divide, the ice or snow action at the lip of the cirque is negligible, but increases in intensity with progress down the cirque wall. With increasing volume the factor of flow increases, and because the cirque structures are practically

unsupported above the basin at the foot, the descending glacier easily transports the rock blocks out of the cirque walls. This is the quarrying phase of corrasion as opposed to the abrading phase at the foot of the cirque, where the most rapid change of channel slope occurs. It will thus be seen that the abrasive action is practically negligible at the upper portions of the cirque walls, while it increases with descent of the walls and reaches a maximum at the cirque foot.

It will thus be evident that the greatest change of slope will occur at the point separating the basin formed by overdeepening action from the upper quarrying action and sapping action. It is easy to see that the basining (or overdeepening) at the cirque foot is due to some heavy stream action, otherwise there could be no marked excavation formed below the local base level with reversed grade down stream.

Perhaps the most important point to bear in mind in connection with the formation of the cirque as it is seen to-day, is now to be discussed. Widespread geological observations have proved that no country is to-day passing through its maximum Ice Age. On the contrary, it has been proved that any glaciers which may exist to-day in any country whatsoever, are only the dwarfed representatives of ice masses, which latter we may call Ice Floods. Furthermore it has been demonstrated that such Ice Floods have only just departed by reason of some cosmopolitan agency.

It will now be interesting to understand the mechanical significance of such glacial decadence in the history of cirque formation. It is evident in the first place that ice is not mobile under ordinary conditions of pressure unless in large volumes, and that whenever opportunity offers, it will escape from conditions of pressure and return to the

condition of a crystalline solid. Therefore upon a considerable reduction in glacial volume, the old flood channel of the ice will be altogether too large for it, and it will be placed in a condition of tension in its attempts to accommodate itself to the channel profiles. Especially will this be the case at the points of maximum interruption of the channel base, such as the huge cutting curves of the Ice Flood, the broad channel floors and in the basins lying along the old glacial thalweg. This tension will be expressed as crevasses, because at the points just enumerated, there will be a minimum of pressure under the ice drought conditions as opposed to the maximum of pressure under the Ice Flood conditions. One would then expect bergschrunds or crevasses to occur at various distinct variations in channel slope. Furthermore there would be a tendency for the glacier at such points to be convex near the centre of the stream, whereas in the Ice Flood the tendency above the cirque foot was to sag by reason of increased mobility and velocity, and to heap itself towards the sides at points a little lower down and nearer the lower portion of the cirque.

Again the tendency of all reduced streams is first to aggrade all the larger irregularities of the channel base, and then this having been done to cut smaller channels along the base of the old and larger channel formed by the flood stream.

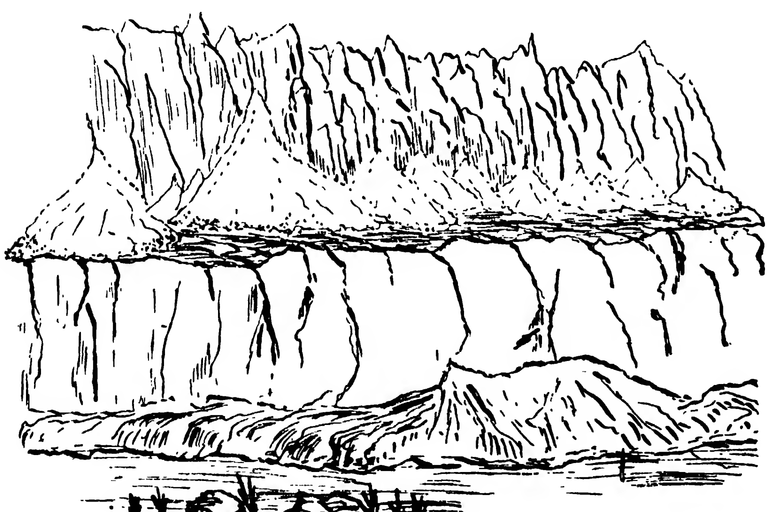
Applied to the cirque and down stream "tread" and "step," this shows that the early action of the reduced glaciers is to fill the basins with débris, by reduction of the vertical measure of corrasive strength, and secondly to forsake the old wide cutting curves and crowd towards the centre or deepest portion of the flood channel and deposit moraines (Fig. 15) in the cutting curves during the process.

Fig. 15.

Rock Creek Cañon, Yosemite Region, illustrating crowding of moraines in terrace form from an old cutting curve towards the central channel.

This is the expression of the reduction of the lateral factor of glacial strength. Then the ice will tend to cut narrower and steeper cirques and valleys along the floors of the old ones. (Fig. 16.)

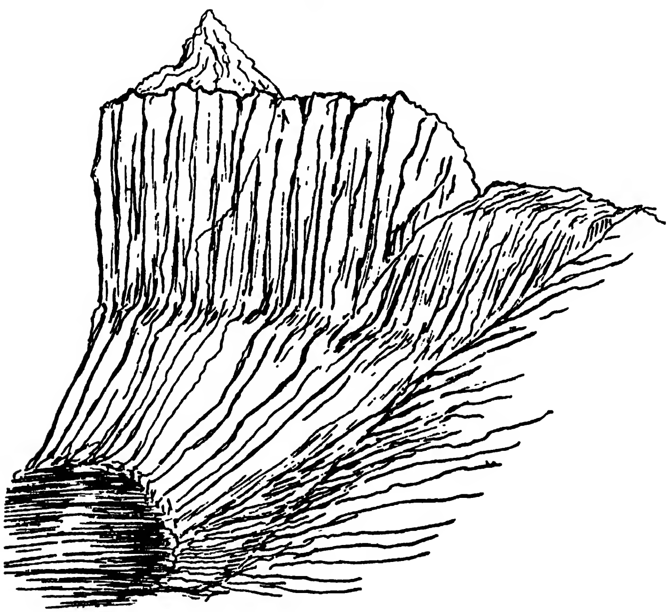
Fig. 16.



Detail of corrasion just below a "cirque" in the Upper Evolution Valley, Yosemite Region. A smaller glacial valley is here seen excavated in the floor of an older glaciation. The remnant of the older floor is partly covered with morainic material and with talus cones.

It is evident that in the case of the cirque the basin must be filled with débris up to a certain point. Again since the cirque at this stage is not filled with ice, its walls will more and more tend to have the atmospheric slope of repose induced in them. Thus the cirque wall which at this stage is free from ice and snow covering in great measure, will be in a state of unstable equilibrium, and will shower down débris on to the reduced glacier which will transport it for short distances and dump it at the earliest opportunity to form lateral and terminal moraines. In a short time then the signs of the old abrasive action will vanish and the cirque wall will be rough and jagged. (Fig. 17). But this implies the development of the amphitheatrical head in

Fig. 17.



Detail of cirque form in Upper Evolution Valley. The basin and slope of corrasion are visible, as is also the upper slope of sapping. The ice and snow have only just disappeared from the lower half of the cirque.

rocks fairly homogeneous, such as the crystallines. In stratified rocks of differential strength the cirques will tend to possess enormously steep heads by such action, because of the exposure of huge vertical walls by such sapping action, for example, those of the Canadian Rockies and Selkirks. The reason for this amphitheatre head (cirque) is that under ordinary atmospheric conditions the fragments of the cirquė wall are acted on only by the constant gravitational force and take the lines of least resistance or quickest descent, producing a symmetrical geometrical figure in so doing.

Origin of the Yosemite and associated valleys.—We are now in a position to understand the later steps in the history of the Yosemite Valley. From the descriptions and figures supplied in the earlier portion of this paper it is evident that the thalweg of the Yosemite in recent time was steep; that it descended in a fairly even manner both from Lake Tenaya and the Little Yosemite along the Tenaya and Merced Channels respectively, to a point somewhat higher than the lip of the Bridal Veil Falls. A pronounced constriction occurred also in the valley between the Cathedral Rocks and El Capitan Dome. During the recent Ice Flood the Yosemite glacier gained enormously kinetic energy during its descent of the steep thalweg and its passage of the constriction at El Capitan. Just in front of this constriction a "step" with "basined" tread was formed.[1] The "step" and "tread" once formed were rapidly enlarged by the process of recession. The heavy quarrying action of the glacier caused the rock structures of the declivity forming the channel slope near El Capitan to be easily removed because of the notable steepness of

[1] From Bridal Veil Falls to El Portal a distance of about 14 miles by coach, the thalweg of the Merced falls rapidly. Relatively little glacial corrasion occurred along this portion of the channel however, because of the rapid disappearance of the glacier by melting.—(Andrews, Corrasion by Gravity Streams, p, 303.)

this same declivity. The immediate result of such action was that the mouth of the Bridal Veil stream was cut off by the glacier, the upper portion of its channel being finally hung up more than 800 feet above the floor of the main channel. During the recession an enormous "step" was formed near the present Hanging Valley of the Yosemite Creek. This "step" must have been at least 2,000 feet in height. It is evident that as the declivity was cut back so rapidly owing to the great steepness of the declivity (in other words, to the great thickness of the structures lying above the local base-level immediately down stream) the glacial energy had no time in which to excavate deep basins below the associated base level, but merely formed a huge tread with relatively shallow basins upon it. Inasmuch again as the immense volume of the structures so removed in the formation of the "step" and "tread" increased the cross section of the Yosemite, so at this later stage the ice which formerly had flowed round the summit of El Capitan and had made a roche moutonnée of it, now had its surface lowered considerably, the glacier not exceeding a depth of 2,000 feet above the present floor of the Yosemite.

This rapid and peculiar change of vertical position set up sapping by lateral glacial action, the lateral however being subordinate to the vertical action. This gives to the Yosemite the appearance of roches moutonnées on the uplands. On the other hand, it is the still later sapping which gives the peculiar and rough appearance to the upper portions of the walls where observers would naturally have looked for signs of abrasion. On passing Glacier Point the great Yosemite "step" and "tread" became duplicated, one following the course of the Tenaya, the other following that of the Merced. Glacier Point was not reached by the ice stream so soon as the huge "steps" of the Tenaya and Merced had been carried some little distance upstream of

this famous Look Out. The strength of the heavy ice stream which descended the Tenaya "step" was immense. So also was that of the stream which came down the Merced thalweg. Enormous blocks of rock were transported from the faces of the giant "steps," the marvellous system of rock-jointing in the Yosemite permitting this action to be easily accomplished. Of course on such declivities compression and abrasion of structures were altogether subordinate to quarrying and transporting action. The giant "steps" therefore, appear to be almost in the form of a staircase, and in cross-section the channel is at times almost of V-shape, because the huge rock masses have simply been hauled out along dominant fault and joint planes.

For the Merced, the two "steps" of the Nevada and Vernal Falls show this marvellous quarrying action and consequent absence of abrasion.

For the Tenaya the deep V-shaped chasm with its impassable thalweg marks a similar action.

But at this stage of the "step" recession along the old thalwegs of the Tenaya and Merced channels the Ice Flood disappeared. From the lips of the two huge steps just mentioned topographical features similar to those which once extended vertically above the present Yosemite Valley floor may be seen stretching along both to Lake Tenaya and along the Little Yosemite. Ice swept domes, roches moutonnés, polished pavements and rounded outlines generally evidence the action along the upper broad reaches of the valleys, while rugged walls and beetling precipices equally attest to the much greater power of the descending ice in forming a channel by the removal of a great declivity.

The earlier stages of glacial decadence were marked by the deposition of moraines in the great ice cutting curves under Cloud's Rest along the Merced Valley. These were

deposited in terrace form as the Merced Glacier decreased in size, and they were crowded over toward the Little Yosemite (See also Fig. 15). Such features evidence the shrinkage of the lateral measure of glacial strength. Then ensued the dropping of moraines near El Portal, and still later at El Capitan. Still later, the polished pavements of Lake Tenaya and the Merced were formed by the gradual obliteration of huge grooves, as the heavier ice action was gradually replaced by the weaker sand-papering action of the dying glaciers. At the same time the walls of Yosemite showered talus on to the huge "tread" of the Yosemite, and the water streams of the melting ice gradually filled up the depressions on the "tread," and converted the whole floor into a great "meadow." In this way the talus and the moraines were in part buried. The bulk of the morainic material had however been crushed to boulders pebbles and mud in the down stream constrictions and swept away later by the water floods.

The depth of alluvium in the Yosemite Valley is doubtless not great, as it merely marks the aggradation of a "tread" which had been formed rapidly as the result of "step" recession, and therefore differs from a fiord basin which has been excavated at the foot of a declivity and near a decided valley constriction.

The lack of typical cirque forms in the Tenaya Gorge and at the Nevada and Vernal Falls is due to the heavy action of the ice in descending the "steps" of recession, such action completely modifying the amphitheatrical form which is mainly the expression of sapping agencies.[1] To see the typical cirque one must ascend the Tenaya, the Merced, or the associated San Joaquin Valleys, to the glacial head waters where one may see the amphitheatres encroaching on each other and each exhibiting more or less the atmos-

[1] "Corrasion by Gravity Streams," Appendix II.

pheric slope of repose.[1] In these forms one does not see exactly the profiles due to the recent glaciation, for since the disappearance of the Ice Age the head of the cirque has been much modified, the atmospheric slope of repose being induced at the present time. Such in brief appear to be the later steps in the history of the Yosemite Valley.

A NOTE ON THE OCCURRENCE OF PENTASTOMES IN AUSTRALIAN CATTLE.

By T. HARVEY JOHNSTON, M.A., B.Sc., and J. BURTON CLELAND, M.D., Ch.M.

(From the Government Bureau of Microbiology, Sydney, New South Wales.)

[*Read before the Royal Society of N. S. Wales, August 3, 1910.*]

WHILST holding a post-mortem at Berry, New South Wales, on some Illawarra cattle suffering from endemic haematuria[2] one of us found a few tiny parasites in the mesenteric glands. The parasites and the glands from two diseased animals were brought back to the Bureau and carefully worked through. The parasite was, on examination, recognised as a larval pentastome, *Pentastomum denticulatum*, Rud., the adult of which is known as *Linguatula serrata*, Fröl. Since this animal has not been identified as far as we know, from any host in Australia, we desire to draw attention to-its presence in New South Wales cattle.[3]

[1] Johnson's vivid description of these cirques is the best known. The Profile of Maturity.—Journ. Geol., Chicago, XI, 1904, pp. 569 – 578.

[2] T. H. Johnston and J. B. Cleland, *Proc. Linn. Soc. N.S.W.*, XXXIV, 1909, p. 510.

[3] We have since come across a reference to the finding of pentastome larvæ in Victoria in cattle affected also with pleuro-pneumonia (T. S. Ralph *Austr. Medical Journal*, X, 1865, p. 6). A statement by Barnard and Park (*Rep. Austr. Assoc. Adv. Sci.*, V, 1893, p. 644) seems to infer that they also unknowingly encountered the parasite in Queensland cattle.

The pentastomes or linguatulids form a group of very degenerate Arachnida, and are now regarded as possessing affinities to the vermiform Acarids. The true position of these limbless Arthropods was for long a matter of speculation,[1] until Leuckart traced the life history of the species under review, showing that in one of the early stages, limbs as well as distinctly acarid characters were present.

Excellent accounts of the life history and general anatomy of this worm are given in various textbooks dealing with human and veterinary parasitology.[2] The main characters of the larva as seen by us were as follows:—The animals were flattened and almost lanceolate, being 5·4 mm. long with a breadth (just behind the anterior end) of about 1·25 mm., tapering fairly rapidly to 0·15 mm. at the posterior end, which was obtusely rounded off. The whole body was finely annulate, 89 rings being counted. The posterior border of each ring possessed a great number of short, strong backwardly-directed spines. Situated anteriorly on the flattened or concave ventral surface were four large strongly curved chitinous claws. These were freely movable and projected prominently when the parasite was viewed laterally. Each claw was provided with a chitinous accessory hook lying just above it. In the mid-line, between the pairs of hooks, the mouth could be recognised as a more or less elliptical aperture leading into the relatively wide intestine. The latter was a simple straight median tube leading to the terminally situated anus.

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1 For a brief summary see Sambon, *Jour. Trop. Med. Hyg.*, XIII, 1910, p. 17 – 24.

2 Cobbold, "Entozoa," 1864, p. 393. Cobbold, "Parasites etc.," 1879, pp. 259 – 263. Railliet, "Traité de Zoologie agricole et médicale," 1895, pp. 616 – 623. Neumann, "Parasites," 2nd edit., Eng. transl., 1905, pp. 476 – 483. Braun, "Animal Parasites of Man," Engl. transl., 1906, p. 378-9. Braun and Lühe, "A Handbook of Practical Parasitology," Engl. transl., 1910, pp. 182-3. Law, "Veterinary Medicine," Vol v, 1903, pp. 215-7. Ostertag, "Handbook of Meat Inspection," 1907, pp. 513 – 520.

In addition to the living larvae found by us, there were present very many calcified cysts embedded in the glands, the parasites evidently having undergone degeneration, as frequently happens in the case of various larval helminths. Ostertag[1] states that he has never observed the formation of a capsule in the lymphatic glands, whereas all the parasites seen by us were distinctly enveloped in a capsule formed by a modification of the surrounding tissues of the gland. *Pentastomum denticulatum* has been recorded from a number of animals such as cattle, rabbits, hares, sheep, goats, camels, certain deer, rats (*Mus decumanus*) and man,[2] most of them being herbivorous. The adult (= *Linguatula serrata*) infests the nasal cavities and frontal sinuses of various hosts (mainly carnivorous), such as dog, wolf, fox, horse, goat, etc., and rarely, man. The larvae usually occur in the liver, lungs or lymphatic glands of the infected host.

They may either reach the exterior by way of the trachea or intestines, to be sniffed up by dogs, etc., or they may gain access to their definitive host by the latter eating the infected organs of the intermediate host, It may be remarked that when human beings have been parasitised by the larval form, its presence had not been suspected until post-mortem examinations revealed the fact. In man the liver seems to be the more common location, whilst in cattle the mesenteric glands are said to be the more frequent habitat. Braun,[3] Railliet, as well as some of the other writers referred to, give details as to the occurrence of the parasite in its larval and adult stages, in human beings.

The occurrence of the pentastome in our cattle presupposes the existence of its adult stage in our dogs, and also suggests the possibility of human beings becoming infected.

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1 Ostertag, *loc. cit.*, p. 518.
3 Braun, *l.c.*, p. 389.
2 For intermediate hosts see Railliet, Braun and others already cited, and also Shipley, *Arch. d. Parasitol.*, I, 1898, p. 58.

The correct name of this parasite seems to be a matter of difficulty. The larva is usually called *P. denticulatum*, Rud., though *Linguatula serrata*, Fröl. is an earlier name and therefore the more correct one. The adult is also variously named by the writers above referred to, the more common names being *L. taenioides*, Rud., and *L. rhinaria*, Pilger. Of these two names the latter is the older, and therefore the better to use. However, the specific name *serrata* was used for the larva by Frölich in 1789, whilst *rhinaria* was used in 1802 by Pilger, and *denticulatum* in 1805 by Rudolphi. The usual method in helminthology appears to be to retain the earliest name applied to the *adult* as the true specific name even though the *larva* may have been named previously. This has led to the name *L. rhinaria*, Pilger and *L. taenioides*, Rud., being used in preference to the older *L. serrata*, Frölich. Sambon, however, accepts the last named as the true name apparently following the "International Code"[1] which is now binding on helminthology as well as other branches of zoology.

The possible causal relationship of this parasite to the endemic haematuria common in bovines in certain of our coastal districts is a matter now under investigation by us. This disease is characterised by the presence of small angiomatous growths with telangiectases in the bladder of infected animals. From time to time, extensive haemorrhages occur from the vascular tumours leading to haematuria and subsequent anaemia, etc. In the only two animals thus affected examined by us for Pentastomes, these were found. It will be necessary of course to ascertain whether healthy cattle in the same district are also affected and whether the parasites can be found in animals from other parts of New South Wales.[2] The discovery of these parasites in the cases referred to, suggests that they may play a rôle of much economic importance, but it would be premature to discuss the question further at present with the limited material and facts at our disposal.

[1] Stiles, S. W., "The International Code of Zoolog. Nomenclature as applied to Medicine," *Bull.* 24, *Hyg. Lab. U.S. Pub. Health*, etc., 1905, p. 24.

[2] Further searching has shown us that it is not uncommon to find pentastomes, generally in small numbers, in the mesenteric glands of cattle from other parts of the State.

NOTES ON THE CONDITION OF THE ATMOSPHERE DURING THE RECENT CONTACT OF THE EARTH WITH THE TAIL OF HALLEY'S COMET.

By H. G. A. Harding, A.S.T.C., Sydney Technical College.
(Communicated by W. J. Clunies Ross, B.Sc.)

[*Read before the Royal Society of N. S. Wales, August 3, 1910.*].

Owing to the possibility of our atmosphere being affected by the recent passage of the earth through the "tail" of Halley's Comet, it was resolved to conduct a series of experiments, to ascertain any appreciable variations in its composition, by analysing samples of air collected before, during, and after the time of contact. The samples were taken daily from suitable positions in the Hornsby district, in calibrated Erlenmeyer flasks, from about a week previous to the date of contact (May 19th) till a week following that event.

The apparatus used in the analyses, was similar to that used by Hesse and Hempel, and experiments were also made with the latter's gas burette, using mercury instead of water as the confining liquid in measuring the gases.

The percentages of oxygen, carbon dioxide and water vapour were very accurately estimated, every precaution being taken to guard against possible errors in the determinations. The oxygen was absorbed by alkaline pyrogallate, water vapour by aspirating a known volume of the sample through fused calcium chloride (saturated with carbon dioxide) and the carbon dioxide by agitation with standard barium hydrate (25 cc.), and the excess titrated with standard oxalic solution. Experiments were also made in absorbing nitrogen by a mixture of lime, metallic sodium and magnesium.

It was found however, that the composition of the atmosphere remained constant throughout, the several constituents not varying appreciably from normal limits.

Samples were also submitted to spectroscopic analysis in partially exhausted tubes, specially prepared by the writer, and here again the results indicated nothing abnormal in the composition of the atmosphere.

ON THE INTERPRETATION OF THE PRECIPITIN REACTION.

By D. A. WELSH, M.A., B.Sc., M.D., M.R.C.P. *Edin.*, and H. G. CHAPMAN, M.D., B.S.

(From the Laboratories of Physiology and of Pathology in the University of Sydney.)

[*Read before the Royal Society of N. S. Wales, September 7, 1910.*]

Introductory.

Phenomena of precipitation:

(*a*) Relation of antiserum to precipitate.

(*b*) Total and partial interactions.

(*c*) Relation of antigen to precipitate.

Phenomena of inhibition.

Conclusions.

References.

Introductory.—The different phenomena of immunisation are but different aspects of the response of the animal body to the introduction of alien substances within its tissues, and the precipitin reaction is one form of this response. When the blood serum of an animal that has received repeated injections of some alien protein is mixed outside the body with a solution of this alien protein, then precipitation may occur. This, apparently one of the simplest of the immunity reactions, is yet one of the hardest to interpret. We do not propose to discuss what corresponding property has been acquired by the blood *in vivo*, nor what is its relation to the general defensive mechanism (1). It is with the interaction of antiserum and antigen, indicated by a precipitate *in vitro*, that we are now concerned.

From the beginning we have looked upon the reaction as taking place between known weights of the interacting substances. In our later work the weighing of the pre-

cipitate marks a further advance in accuracy. The remarkable nature of the precipitate is thus revealed. For, if our interpretation be correct, the precipitate is formed mainly of those constituents of the antiserum that give the antiserum its specific precipitable character. It is probable that the specific antisubstance (precipitin) brings down with it from the antiserum non-specific molecules (*e.g.* complement) which also go to form the precipitate. It is probable also that the antigen enters to a relatively slight extent into the composition of the precipitate. But all our work tends to show that the main mass of the precipitate is composed of antisubstance (precipitin) which can be weighed. A ponderable antisubstance has hitherto been unknown, but in the precipitate of a precipitin reaction we have a remarkably near approximation to such a substance.

Phenomena of Precipitation: (*a*) relation of antiserum to precipitate.—The original interpretation of the precipitin reaction was that the antiserum contained "coagulin" or "precipitin" which had the power of throwing the antigen (homologous protein) out of solution. "Très généralement, en effet, le sérum d'un animal d'espèce A, injecté de sérum d'espèce B, précipite ce sérum B" (2). It was admitted that some portion of the precipitate might be derived from the antiserum (3, 4, 5, 6). It was also said that the precipitin combined in equivalent quantities with the antigen to form the precipitate (7). Nevertheless the fundamental assumption was made that the main source of the precipitate was the antigen (homologous protein) which was therefore known as the "precipitable substance." It was suggested that the precipitin reaction was analogous to bacterial agglutination, and that, in some similar manner, precipitins agglutinated and precipitated protein molecules from solutions of the antigen (8, 9).

At an early stage of our work on precipitins we found that this interpetation of the reaction was not borne out

by experiment. It has long been known that the precipitin reaction is one of extreme delicacy, that recognisable precipitates may be obtained with minute traces of the antigen (homologous protein) in solution. We have been able to go a step further, and to show that recognisable precipitates can be obtained from a mixture of antiserum and antigen, although the total amount of protein in the antigen solution is too small to be revealed by any chemical precipitant of protein (11, 12). Obviously the visible precipitate can not have come from the invisible amount of antigen. It must therefore have been derived from the antiserum.

At a later stage we obtained corresponding results with quantities of antigen and of precipitate that were large enough to be measured by weight (13). Thus 1 mg. hen egg-white (antigen) interacting with 52 cc. of antisera for hen egg-white yielded a precipitate weighing 25·9 mg., and the superfluid still contained antigen in solution. Obviously again a precipitate weighing more than 25 mg. can not have been derived from an amount of antigen weighing only 1 mg. and still recognisable in the superfluid. The antiserum must therefore be the main source of the "precipitable substance."[1]

Further study of the reaction by weighing the precipitates (14, 15) has shown that the weight of the precipitate is directly proportional to the amount of antiserum, and independent of the quantity of antigen, provided that the antigen is in sufficient quantity to yield the full precipitate from the amount of antiserum employed. With this proviso, if, in a series of tubes, 1 cc., 2 cc., 3 cc., etc. antiserum interact with 100 mg. antigen in a volume of 50 cc. saline solution, the dried precipitates will show the ratio in their weights of 1, 2, 3, etc.; and the superfluids removed from

[1] Moll (32) and Rodet (33) had independently reached a similar conclusion.

the deposits will yield no further precipitate on the addition of antigen. With the same proviso, the weights of the precipitates will be the same and will show the same ratio as the amounts of antiserum, although the quantity of antigen be increased to 200, 300, 400, or 500 mg. or be diminished to 50 mg. These gravimetric experiments demonstrate what our earlier work has indicated (12, 16), that each cubic centimetre of antiserum has a definite "precipitable content" which may be thrown from solution by a certain amount (or concentration) of the antigen.[1] We have already explained that "precipitable content" is not necessarily equivalent to "precipitin," since the "precipitin" may carry down with it non-specific molecules from the antiserum.

A few illustrative experiments are recorded in the following Table I. The interactions were conducted in aseptic conditions and were allowed to proceed for 48 or for 72 hours, when the deposits were carefully separated, washed,

Table I.

No.	Antigen and antiserum.	Volume of antiserum. Cc.	Weight of dried protein (antigen) Mg.	Volume of saline solution. Cc.	Weight of precipitate Mg.	Weight of precipitate per cc. antiserum. Mg.
1	Horse serum 57	2·5	100	50	3·7	1·5
2	Horse serum 57	2·5	100	50	3·5	1·4
3	Hen egg-white 59	2·0	134	50	8·6	4·3
4	Hen egg-white 59	3·0	134	50	12·5	4·2
5	Hen egg-white 59	4·0	134	50	16·7	4·2
6	Horse serum 53	2·5	50	50	2·0	0·8
7	Horse serum 53	5·0	200	50	4·0	0·8
8	Horse serum 56	5·0	100	50	10·4	2·1
9	Horse serum 56	10·0	100	50	20·0	2·0

[1] We have not yet sufficient evidence to decide whether the amount (equivalent quantities) or the concentration of the antigen determines the precipitation from the antiserum.

dried and weighed.[1] The nature of the protein used to immunise the rabbit and interact with the resultant antiserum is given under the heading "antigen and antiserum."

Incidentally these observations show that the precipitable content of different antisera varies greatly, from 0·8 mg. to 4·2 mg. per cc. of antiserum in those under consideration. The conclusion that the precipitate must be composed mainly of constituents of the antiserum has been endorsed by Adami (17), and by Arrhenius (18) who states, apropos of the interaction of small quantities of sheep serum and its antiserum, "Der Hauptttheil des Präzipitäts stammt danach wahrscheinlich aus dem Präzipitin."

(*b*) **Total and partial interactions.**—One reason for the divergent views held by other observers lies in the failure to discriminate between total and partial interactions. It is a common experience that, when increasing quantities of antigen interact with a fixed amount of antiserum, increasing amounts of precipitate may be obtained, the usual inference being that each increment of precipitate is derived from each increment of antigen. We find, however, that this observation holds good only up to a certain point which varies for each antiserum. After a certain quantity (and concentration) of antigen have been reached no further precipitate is obtainable from a given amount of antiserum by any further addiment of antigen. We interpret this to mean that it is possible to discharge practically the whole of the precipitable content of an antiserum by a sufficiency of antigen, and we distinguish this as a total interaction.

Different antisera, however, vary greatly in respect of the amount (and concentration) of antigen required to yield this maximal precipitate from fixed amounts of the antisera.

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[1] A more detailed account of our procedure is given in Reference (14) from which these tables are taken, and also in Reference (15).

This we have expressed by saying that antisera are characterised by different degrees of precipitability (12, 16). When the antigen is insufficient to give the maximal precipitate from the antiserum, then the interaction is only partial, and further additions of antigen will continue to give further precipitates until the full precipitate has been thrown out. Many precipitin antisera are characterised by high precipitability, and are therefore likely to give such partial interactions.

Our earlier experiments on these lines, based on the volumetric estimation of small precipitates, are supported by our later results of weighing larger precipitates. Two illustrative experiments are given in Tables II and III. In each experiment constant volumes of an antiserum (prepared in a rabbit with hen egg-white) were allowed to interact with increasing weights of antigen (dried hen egg-white), and the precipitates at 48 hours were washed, dried and weighed. A different hen egg antiserum was used in each experiment.

Table II.

No.	Volume of antiserum. cc.	Weight of antigen. Mg.	Volume of saline solution. cc.	Weight of precipitate. Mg.	Weight of precipitate per cc. of antiserum. Mg.
1	3	1 44	50	1·0	0 33
2	3	3 6	50	1·5	0·5
3	3	7·2	50	2·0	0·67
4	3	14·4	50	2·7	0·9
5	3	28·8	50	4·2	1·4
6	3	144·0	50	6·5	2·2

In the first experiment (Table II) the amount of deposit continued to augment with each increase of the antigen, and the whole of the precipitable substance was not thrown out of 3 cc. of the antiserum by nearly 29 mg. of the antigen. This antiserum is characterised by a considerable precipitable content (at least 2·2 mg. per cc. of antiserum), and high precipitability. It is just the kind of antiserum

that lends support to the common view of the precipitin reaction, since in the earlier partial interactions (Nos. 1 to 5) the weight of precipitate is increased with increasing weights of antigen.

Table III.

No.	Volume of antiserum. cc.	Weight of antigen. Mg.	Volume of saline solution. cc.	Weight of precipitate. Mg.	Weight of precipitate per cc. of antiserum. Mg.
1	2	14·4	50	3·2	1·6
2	2	36 0	50	3 5	1.75
3	2	144·0	50	3 4	1·7
4	2	432·0	50	3·4	1·7

In the second experiment (Table III) 14·4 mg. antigen served completely to precipitate the content from 2 cc. antiserum, and further increments of antigen, even to thirty-fold, did not increase, nor diminish, the weight of precipitate. This antiserum is characterised by a moderate precipitable content (about 1·7 mg. per cc. of antiserum) and a relatively low precipitability. In these total interactions the weight of precipitate is independent of the weight of antigen.

These observations show that it is only in partial interactions that the weight of the precipitate alters with the weight of antigen (*cf*. Table II). In a total interaction the precipitate has reached a maximal weight, and does not vary with further additions of antigen (*cf*. Table III).

(*c*) **Relation of antigen to precipitate.**—When a fixed quantity of the antigen, however minute, is allowed to interact with successive amounts of the antiserum, the antigen is not completely removed from the superfluid. In many of our experiments with quite small amounts of antigen and relatively large amounts of antiserum, we had no evidence that the antigen was sensibly diminished. We found that the superfluids were capable of interacting again and again to yield similar precipitates with fresh addiments

of antiserum, and that, as the concentration of antiserum increased, the precipitate also tended to increase (12).[1]

In the interactions of ponderable quantities of antigen with antiserum, we have no direct evidence of the amount of antigen present in the precipitate; but the following facts indicate that it is a quantity small in comparison with that derived from the antiserum. 1. Each cubic centimetre of antiserum has a definite precipitable content, and the weight of precipitate is proportional to the weight of antiserum (*v. supra*). 2. The maximal weight of precipitate from a given amount of antiserum is the same whether it is discharged by a single quantity or by successive smaller quantities of antigen (15). 3. In total interactions the weight of precipitate is independent of the weight of antigen (*v. supra*). 4. In partial interactions the weight of precipitate may be many times greater than the weight of antigen when the quantity of the latter is small, *e.g.* 1 mg. or 5 mg. (13, 15).

These observations are not inconsistent with the hypothesis that antigen and antiserum combine to form the precipitate, but they indicate that it is erroneous to speak of the precipitin of the antiserum precipitating the antigen, in other words, they indicate that the antigen is not the true precipitable substance.

Arrhenius and Hamburger (20) have brought forward evidence in favour of the interaction taking place between equivalent quantities of antigen and of precipitin. Their experiments do not appear to be opposed to ours. They deal rather with another aspect of the question, studied in different experimental conditions. Arrhenius[2] (22) states

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[1] An interesting corroboration is supplied by Hunter (19), who, working with precipitins for snake venom, found that the toxicity of his superfluids was not diminished at the end of a precipitin reaction.

[2] Arrhenius (21) had previously said, "This seems to indicate that the whole quantity of the albuminous substances in A (antigen) and only a small part of those in B (precipitin) enter into the precipitates."

that the precipitate formed with small quantities of antigen must be composed mainly of precipitin, and, from his equation of equilibrium

$$\frac{A-P}{V} \times \frac{B-P}{V} = K$$

it follows that his large precipitates must contain proportions of antigen and antiserum similar to those contained in his small precipitates. Thus a small precipitate of 2 units ($P=2$) contains 2 equivalents of A (antigen) and 2 equivalents of B (precipitin; and a large precipitate of 64 units ($P=64$) contains 64 equivalents of A and 64 equivalents of B. If, as Arrhenius states, the small precipitate is composed mainly of precipitin, then, on his own hypothesis the large precipitate is in the same ratio composed of precipitin. Arrhenius (23) also points out that the precipitates deviating complement in the " deviation test of Moreschi" must be derived mainly from precipitin—a fact which we fully recognise (24).

The experiments of Von Dungern (25), P. T. Müller (26, 27), Fleischmann and Michaelis (28) have led them to the view that a diminution of both components of the precipitate (antigen and antibody) occurs in the interaction; and that, in favourable circumstances, both components may be completely removed from the solution. The precipitate is therefore composed of an insoluble compound of both components, neither of which acts as a ferment on the other. If a considerable mass of precipitin reacts with a small mass of "precipitable substance," the precipitate is formed of much precipitin and little "precipitable substance." If mean masses of both substances interact, the precipitate contains both components in equal proportion.

Von Dungern (25) mixed constant amounts of antiserum with ascending quantities of antigen. He then tested the superfluids above the precipitates for precipitin and for

"precipitable substance." To this end he added a drop of antiserum and a drop of antigen to separate drops of each superfluid. With the microscope he sought twenty minutes later for a precipitate, and in each series he found a "middle zone" in which the superfluid gave no precipitate with antiserum nor with antigen. He concluded that in this "middle zone" of the series the precipitate contained the whole of the precipitin and antigen of the original mixtures. He also made certain adsorption experiments to show the variable composition of the precipitate.

We have carried out many thousands of interactions of the type employed by Von Dungern, and we have tested the superfluids with both antiserum and antigen (12, 16). But we have found that in every case the subsequent addition of antiserum has led to the formation of a further precipitate. The subsequent addition of antigen has, or has not, yielded a precipitate, according as the original interaction was partial or total (*v. supra*). We would draw attention to the larger quantities of superfluid examined by us, and the much greater time—frequently 48 hours—allowed for interaction.

P. T. Müller (26) has compared the effect of lactoserum on milk with the coagulation of caseinogen by rennin. He has shown that lactoserum precipitates casein, and in many other ways resembles rennin, *e.g.* precipitation by lactoserum is dependent on the presence of the salts of lime or certain other divalent elements. The close similarity between the actions of lactoserum and rennin indicates that antisera prepared by injection of milk differ fundamentally in their action from antisera prepared with blood serum and egg-white.

Phenomena of inhibition.—We have elsewhere discussed our interpretation of this phenomenon and the bearing of our experiments on Ehrlich's hypothesis (29, 30). If

inhibition were brought about by inactive precipitin (precipitoid) interacting with molecules of antigen, and thus preventing the precipitating action of any active precipitin that may be added, then it should be possible to overcome the inhibition by an excess of antigen, thus providing disengaged molecules to interact with the active precipitin. But in our experiments, when inhibition was complete, we have never been able to overcome the inhibition by any further addition of antigen. (In these experiments the amount of antigen originally present was sufficient to discharge the greater part of the precipitable content of the antiserum). In similar circumstances we have usually been able to overcome the inhibition by a further addition of antiserum—an observation which by itself is not inconsistent with Ehrlich's hypothesis and the theory of mass action.

When regard is paid to the exact amounts of the interacting substances in an inhibition experiment, further difficulties arise, since unheated antiserum is never able completely to neutralise the antigen, while the same quantity of heated antiserum may completely inhibit precipitation from like quantities. It would then be necessary to assume that the combining affinities of precipitoid could be effectively distributed over a much greater number of molecules of antigen than could those of precipitin.

Without going into detail, we may say that our results are consistent with the hypothesis that a heated inhibitory antiserum acts not on the antigen, nor on the antiserum, but on the product of their interaction—the precipitate—and that inhibitory action is of the nature of a solution of precipitate (29, 30). There appears to be a quantitative relation between the amount of heated antiserum and the amount of precipitate that it will inhibit (dissolve). The fact that inhibition can not be overcome by excess of antigen

(the original antigen being sufficient to neutralise to greater part of the antiserum) is explained by our finding that, in these circumstances, no marked increase of precipitate occurs. The further fact that, in similar conditions, an increase of unheated antiserum can overcome the inhibition, is consistent with our finding that there is always sufficient antigen left to produce fresh precipitates with fresh addiments of antiserum.

We may add that our precipitation (11, 31) and inhibition (29, 30) experiments with closely related heterologous proteins support our interpretation of the interaction of antisera with specific antigens, and so strengthen our general position.

Conclusions.—

1. The main mass of the precipitate is formed by constituents of the antiserum.
2. There is a close relationship between the weight of precipitate and the amount of antiserum (*cf.* Table I).
3. In total interactions the weight of precipitate is independent of the weight of antigen (*cf.* Table III).
4. In partial interactions the weight of precipitate is conditioned by the quantity of antigen (*cf.* Table II).
5. It is therefore erroneous to speak of the precipitin of the antiserum coagulating the antigen, or to regard the antigen as the precipitable substance.
6. Inhibition phenomena are inconsistent with the hypothesis that precipitoid is developed, but are consistent with the finding that heated antisera act directly on precipitate by specific solvent action.
7. Our interpretation of the precipitin reaction appears to have important practical bearings.
   (*a*) On the identification of the specific origin of proteins, and on the separation of closely related species (11, 31).

(b) The determination of the value of morphological characters of the orders, genera, and species of plants, as suggested by one of us (24).

(c) On the improvement of methods for testing the interaction of antigen and antiserum by the deviation of complement.

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"STONE ROLLS" IN THE BULLI COAL SEAM OF NEW SOUTH WALES.

By W. G. WOOLNOUGH, D.Sc., F.G.S., Assistant Lecturer in Geology and Mineralogy, University of Sydney.

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

THE various interruptions to the continuity of the coal in those seams which are worked commercially have more than academic interest. The constantly recurring industrial disputes owe their origin, in no small measure, to the difficulties experienced in framing satisfactory agreements for the working of "deficiency places" where the miner cannot, under ordinary circumstances, make what he considers a fair living wage. In the Illawarra coalfield the chief causes of such interruptions are faults, volcanic dykes, "washouts," and "stone rolls." It is with the last of these that this brief note deals.

The descending section of the Illawarra Coal Measures and associated rocks, so far as it concerns the present question, is as follows (*c.f.* also fig. 6):—

Basal Beds of Narrabeen Stage (Hawkesbury Series).
Contemporaneously eroded junction Bulli Coal Seam.
Bulli Coal Seam.
Floor Shale of Bulli Seam.
"Four-foot sandstone"—roof of the Four-foot seam.
Four-foot seam.
Floor Shale of Four-foot seam.

All these beds have a very gentle fall towards the west at the rate of about 200 feet in a mile.

The basal beds of the Narrabeen Stage consist of a porous sandstone or conglomerate resting directly upon the somewhat eroded surface of the Bulli Coal Measures.

At Mount Kembla the erosion has cut partially through the main coal seam and has very seriously reduced its workable thickness. In the more northerly collieries the coal is only locally affected by washouts, and there is usually a thin but variable bed of shale between the coal and the sandstone.

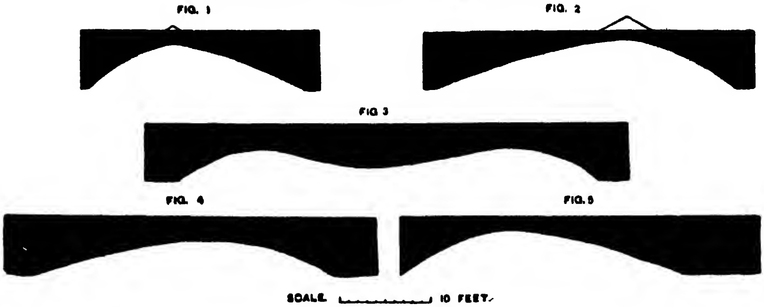
The Bulli Seam has an average thickness of about 7 feet in the southern part of the district. It is a strongly laminated, hard steam coal. It is somewhat jointed, and for the most part these "backs" are vertical. The coal is somewhat porous, some laminae more so than others, a distinction which is brought out in the older mine workings by the selective growth of mould on the damp bands.

The floor of the Bulli Seam is a dense fine-grained shale of very uniform character throughout, quite similar to the Wianamatta Shale of the Sydney area. It is apparently very impervious to moisture.

The four foot sandstone, so called because it forms the roof of the four foot seam, at Mount Keira is upwards of 30 feet in thickness, but a little further north it thins down to 10 feet.

The "stone rolls" take the form of long ridges of the floor shale of the Bulli Seam with a fairly constant trend about N. 40° W. to S. 40° E. They are not perfectly straight and in some cases swing round in a direction 20° nearer the meridian. The average strike of the axes of the rolls is parallel to a well defined axis of weakness in the district, since the faults which occur at intervals trend in about the same direction. In addition to the main rolls there are occasionally encountered rolls at right angles to them, called locally "tie rolls." The occurrence of the rolls is rather limited, they appear to extend from Mount Kembla on the south to North Bulli on the north.

STONE ROLLS IN THE BULLI COAL SEAM OF N.S. WALES.



Figures 1 to 5 (inclusive) represent, to scale, the forms of some characteristic "Stone Rolls" in the Mount Keira Colliery. In figs. 1 and 2 the small triangle at the top indicates the amount of disturbance of the roof.

STONE ROLLS IN THE BULLI COAL SEAM OF N.S. WALES.

FIG. 6

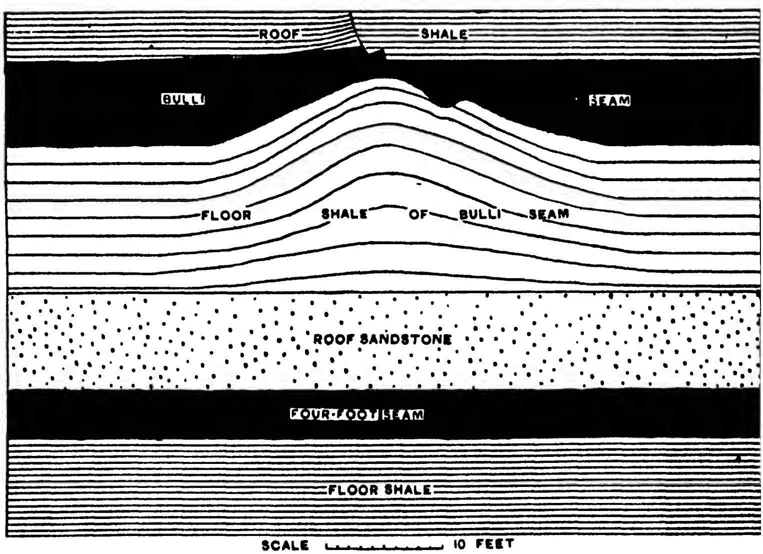


Figure 6. Section of the beds associated with a large "roll" in the South Bulli Colliery, from a drawing kindly supplied by Mr. H. L. Garlick. The Bulli Seam and its roof and floor have been affected, but the four foot seam is not altered at all.

In cross section the rolls of medium size appear as more or less symmetrical upheavals of the floor shale. The forms and dimensions of some of these are shown in Figs. 1, 2, 4, 5, and 6. Fig. 3 shows a double crowned roll. The proximity of such rolls is heralded usually by a slight thickening of the coal, then by a gradual thinning. At the same time the joints or "backs" begin to incline slightly, and this becomes more and more marked as the working progresses up the side of the roll. In many instances, as was pointed out to me by Mr. Thomas Bissell (Mount Keira), a band of pyrites puts in along the floor of the seam. At the crest of the roll the thickness of the coal is reduced below the average thickness by an amount equal to the height of the roll; *with rolls of average dimensions, however, the roof is affected not at all or only very slightly.*

At the highest point of the roll the "backs" are again vertical, but they become inclined as we pass beyond this point, so that their arrangement may be described as radial or fan-shaped. That the coal has suffered considerable compression is indicated by its comparative hardness and density; in both properties there is a marked increase as compared with the ordinary coal at a distance from a roll. The following figures afford some idea of the degree of the compression, while the miners' experience indicates the superior hardness:

Specific gravity of coal from crest of a roll ...	1·39
Ditto, ditto, 20 yards from the nearest roll...	1·15
Compression	20%

It should be remarked that the popular idea—that a good deal of coal is lost on account of the roll—is incorrect. Some of the coal is compressed, some is rolled out to the sides, but material loss there is none. The floor rocks also show evidence of powerful compression in the roll. The shale is brightly polished and slickensided.

In the case of very large rolls the effects above described are accentuated. The coal over the crest of the roll has been forced away to the sides so that the floor rocks come into contact with the roof. The roof also is affected and takes the form of the top of the roll. In extreme cases the crest of the roll is faulted, as in Fig. 6 (from a drawing supplied by Mr. H. L. Garlick, of South Bulli).

Further evidence of compression is afforded by the phenomena of the basaltic intrusions in the coal seam. Basalt dykes are numerous and, where they intersect the coal seam, they often spread out into extensive sills. In at least one instance in the Mount Keira Mine such a sill has been abruptly truncated at the crest of a " tie roll " the density of the coal being sufficient to prevent further spreading along the plane of the seam.

According to Mr. Garlick, who has made these rolls the subject of careful study, if the roll is traced downwards it is found to die out gradually. The four foot sandstone is never affected, and the underlying four foot seam shows no trace of disturbance.

Cause of the Rolls.—The phenomena of compression described above point to the folding of the floor being long subsequent to the date of formation of the coal. This negatives the suggestion that the rolls are due to slip in the unconsolidated muds of the coal swamp as a result of local overloading with river sediment. Further, there is no evidence, which I have seen, of the occurrence of gravel banks competent to produce such an effect.

That the rolls are not ordinary contraction folds, caused by uniform shrinkage of the earth's crust, is proved by their localization in the floor of the seam. If caused by so far reaching a force as that mentioned they would certainly affect the associated beds also.

We are therefore driven to some cause inherent in the rocks of the floor; and I suggest that *the rolls are of the nature of expansion "folds" due to the swelling up of the shale as a result of hydration or oxidation or both.* It has been shown that the overlying rocks are all somewhat porous so that the access of water carrying oxygen is easily accounted for. A similar effect is very widespread in the Wianamatta Shales of the Sydney area, and the folds are very conspicuous features in almost all the deeper railway cuttings between Sydney and Penrith. In this case we have all stages of development from simple anticlines, through overfolds, to overthrust faults, but when traced downwards the disturbance dies out when layers of shale are met with which are fresh and free from oxidation.

The relationship of any of the rolls to the faults is by no means clear. Both have a common general trend, and are frequently found in association. The faults, so far as I have been able to determine, are always normal and not reversed, as we should expect, if they were due to expansion. They have throws varying from a few inches to upwards of a hundred feet. I am inclined to think the faults antedate the formation of the rolls, and that the fault blocks have formed the resistant blocks against which the shales have been folded subsequently, The superior limit of age of the rolls is indicated by the interesting occurrence, noted on page 383, of a sill being truncated by the compression effect of the roll. The basalt sills are probably Tertiary, hence the rolls must be Pre-Tertiary, and they are probably Post-Triassic.

In conclusion I wish to express my thanks to all those who have assisted me in the investigation of this interesting problem, and especially to Messrs. — Jones, and T. Bissell of Mount Keira, and Messrs. — Sellars and H. L. Garlick of South Bulli.

Appendix.—Chemical analyses of the two samples of coal whose specific gravities are given on p. 337, have been made by Mr. L. Wright of the Chemical Department, University of Sydney, with the following results:—

	No. 1. Coal away from roll.	No. 2. Coal from crest of roll.
Moisture	1·07 ...	1·48
Volatile hydrocarbons ...	25·13 ...	22·77
Fixed carbon	62·12 ...	65·53
Ash	11·68 ...	10·22
	100·00	100·00

From these results it is apparent that the compression and hardening of the coal is almost entirely a mechanical process. Contrary to expectation the rise in fixed carbon and corresponding decrease in volatile hydro-carbons is very small. If much heat had been developed in the formation of the roll, the coal would certainly have given evidence of the fact in distillation of the volatile constituents. We may conclude, then, that the expansion in the floor rocks was very gradual. I desire to express my thanks to Mr. Wright for his kindness in making these analyses.

STUDIES IN STATISTICAL REPRESENTATION.

On the Nature and Computation of the Curve

$$y = Ax^{m}\, e^{nx^{p}}$$

By G. H. Knibbs, C.M.G., F.S.S., F.R.A.S., etc.,
Commonwealth Statistician.

[*Read before the Royal Society of N. S. Wales, September 7, 1910.*]

1. The curve and its origination.
2. Synthesis of the curve.
3. Points of inflexion of constituent curves.
4. Variety of the form of curve.
5. Logarithmic homologue of curve.
6. Critical points of curve.
7. Determination of constants of curve.
8. Weight of results.
9. Algorithm of practical solution.
10. Integral of the curve.
11. Special cases of integration.
12. Particular values of abscissa.
13. The constant A.
14. Approximate integration.

1. The curve and its origination.—A single expression which, by variations of its constants, will reproduce the great majority of the curves required to represent data furnished by physical observations and statistical enumerations has certain obvious advantages, and an appropriate study of the nature of the variation of the constants of such an expression would unquestionably go far to facilitate their rational interpretation, and reveal their inter-relations. I propose to shew that a single expression will cover a great range of requirements, excepting however those curves which, following Helguero,[1] may be called dimorphic

[1] *Biometrika*, Vol. III, pp. 84 - 98; Vol. IV, pp. 230 - 232.

or polymorphic. Even these may be covered by the sum of two or more curves of the same type as the above.

In the expression

$$y = Ax^{m}e^{nx^{p}} \dots\dots\dots\dots (1)$$

which may also be written

$$y = Ae^{m \log x \pm nx^{p}} \dots\dots\dots\dots (1a)$$

It may primarily be noted that the modulus of x, or the unit by which x is measured, is not material. For write $x = x/c$, then

$$y = \frac{A}{c^{m}} x^{m} e^{\frac{n}{c^{p}} x^{p}} \dots\dots\dots\dots (2)$$

Hence, if we put $A' = A/c^{m}$ and $n' = n/c^{p}$, we shall have

$$y = A'x^{m}e^{n'x^{p}} \dots\dots\dots\dots (2a),$$

that is to say the *form* of the function is unchanged, the indices m and p are also unchanged; the factor A and index n are alone altered.

An examination of the tracings of this curve, hereinafter given, shews that it is adapted to represent a large variety of physical results and is of wide application. In the present instance, the consideration is, in the main, restricted to its employment for the purpose of statistical representation; this will sufficiently reveal the utility of the curve and dispose of the necessity of fully discussing the grave limitations of the conventions of ordinary Algebra,[1] and their incidence in practical solutions.

The manner in which the type of curve under consideration can be conceived to originate, may be presented as follows,—

When the distribution of the ordinates (frequency) of a curve, about either side of the maximum or minimum

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[1] Which for example do not distinguish the products $(+a)$ $(+b)$ and $(-a)$ $(+b)$; in which also is involved the saltatory character of the fields of representation for $y = x^{m}$ where m may be fractional and positive and negative, etc.; and in which too $\log -x$ or $\log -(-x)$ demands special consideration.

ordinate (the mode, etc) is asymmetrical, it is obvious that the fundamental assumption which furnishes the ordinary "probability curve" must be modified, since if the y axis be (arbitrarily) taken at the maximum or minimum ordinate the rate of variation of frequency is not the same for negative as for positive values of x.

We may suppose that any sufficiently small length of the curve may be represented, with any required degree of precision, by *some* probability curve

$$y = Ce^{-x^2/k^2} = e^{-\frac{x^2}{k^2}+c} \text{ ....(3)}$$

in which

$$e^c = C, \text{ or } c = \log_e C \text{ ....(3a)}$$

Since under the hypothesis x has determinate values, k, the modulus of x, may be regarded as exact only for the part of the curve in question, and to have a different value for other parts of the curve. Obviously we may suppose that both C or c and k^2 are assignable functions of x, that is to say (3) becomes

$$y = F'(x)e^{-x^2/f(x)} \text{ or } e^{-x^2/f(x)+F(x)} \text{.........(4)}$$

and the functions F' or F and f may of course be as complex as the case may require and include any necessary constants. When it is legitimate to suppose that

$$F(x) = \alpha + \beta \log (\pm x) \text{..............(5)}^1$$

$$f(x) = \gamma x^s \text{ ....(5a)}$$

these expressions substituted in the above give

$$y = e^{-x^2/\gamma x^s + \alpha + \beta \log (\pm x)} \text{ ....(6)}$$

hence putting

$$p = 2-s;\ n = -1/\gamma;\ A' = e^\alpha \text{ or } \log A = \alpha;\ m = \beta \text{...(6a)}$$

the above expression is seen to be equal to

$$y = e^\alpha e^{nx^{2-s}+\beta \log (\pm x)} = Ax^m e^{nx^p} \text{ ....(7).}$$

It is evident however that as x approaches a zero value β (or m) would also require to approach a zero value, in

---

[1] If x be negative log $-(x)$ may generally be regarded as log $+x$.

order that the curve may represent a series of probability curves with changing moduli with the value $y=A$ for $x=0$.

It is therefore inappropriate in such case to introduce the term x^m, or in other words to make β or m other than zero, if the y axis is to coincide with the maximum value of the ordinate. On the other hand, if the ordinate to the curve at its origin is to be zero, the term $\beta \log x$, with β positive, ensures this, since $\log 0 = -\infty$. It is obvious that suitable manipulation of the values of γ, s, a and β enables the curve to be fitted to a very wide range of results, without departing from the conception that it may be regarded as being built up of elements of ordinary probability curves with different moduli.

A close examination of a large number of graduated statistical curves will disclose the fact that the variation of frequency with change of the value of the variable cannot ordinarily be subsumed under the conception of a curve of unchanging modulus, or even of moduli progressively changing in any very uniform manner.

2. Synthesis of the curve.—Neglecting the general factor A in expression (1) the curve represented by it has ordinates which are the product of two variable factors, viz. x^m and

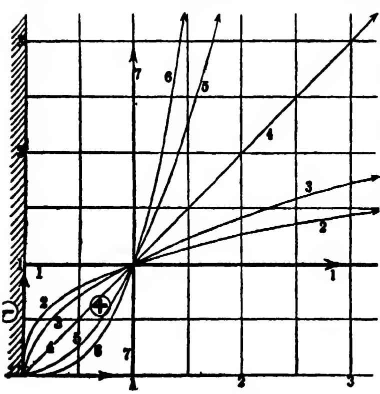

Fig. 1.

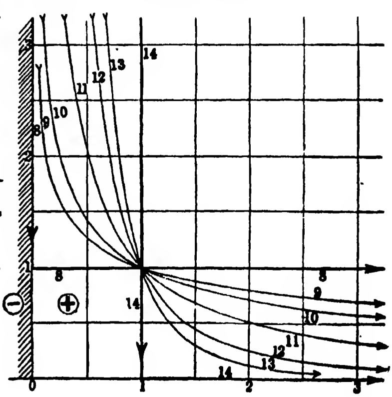

Fig. 2.

e^{nx^p}. For *positive* values of x the expression $y = x^m$ is a series of parabolas for positive values of m, and a series of hyperbolas for negative values of m as shewn in the following figures, viz., curves 1 to 7, Fig. 1, and curves 8 to 14, Fig. 2.

Whatever the value of m, if it be positive[1] the curves $y = x^m$ will all pass through the points $x=0$, $y=0$, and $x=1$, $y=1$; but negative[1] through the points $x=0$, $y=\infty$; $x=1$, $y=1$; $x=\infty$, $y=0$.

If y is to be positive throughout, then for *negative* values of x, the ordinary convention which assigns a different quadrant for the representation of $y=x^{2r}$ and $y=x^{2r+1}$, (r being any integer) must be abandoned, and the curves $y=x^m$ for negative values of x, will be symmetrically situated on the opposite side of the Oy axis, *i.e.* will be the *images* of the curves for positive values. Thus the quadrant xOy is the *region* of y for positive values of x, and the quadrant yOx that for negative values. See Figs. 1 and 2.

In general m, n and p will be regarded as susceptible of increase by indefinitely small quantities, and it is for this reason also that the field in graphical representation does not necessarily follow the usual convention, viz., that which places say $(-x)^2$ in a different field to $(-x)^3$.

If y may also be negative, then the ordinary convention *may* be followed when necessary. In all cases the consequences of the particular convention adopted must be carefully attended to.

The curve $y = e^{nx^p}$ illustrated in Figs. 3, 4, 4a and 4b is less simply described. Differentiating this expression

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[1] Thus if the value be $0 + \delta m$ the curve will not be identical with the curve for the value $0 - \delta m$, where $0 \pm \delta m$ are values of m slightly greater or *less than* zero. See heavy lines on Figs. 1 and 2.

$$dy/dx = npx^{p-1}\,e^{nx^p} \ldots\ldots\ldots\ldots\ldots(8)$$

from which it is evident there is neither maximum nor minimum value unless n, p, or x be zero.

Restricting the consideration of the expression to those curves which correspond to positive values of x, they will, for zero values of the abscissa, and whatever the values of p or n, pass through one of the points defined hereunder according to the conditions specified, viz:—

Origin of curve	$x=0,\ y=0$;	$x=0,\ y=1$;	$x=0,\ y=\infty$
Condition	$p-$ and $n-$;	$p+$ and $n\pm$;	$p-$ and $n+$

When the abscissa has the value unity, all the curves pass through the point $x=1$, $y=e^n$, the values of y which define the points for negative values of n being the reciprocals of those for numerically equal but positive values of n.

The asymptotes to the various members of the system are the axes, and also the line $y=1$, the $y-$ axis and the line $y=1$ being the asymptotes for the curves for p negative. The values of y are greater than unity when n is positive, and less than unity when n is negative.

When n is negative and p is positive, the asymptote is the line $y = 0$. The effect of decreasing the numerical value of n is to cause the points 'N' and 'n' (see Fig. 4) to move toward the line $y=1$, with which they become identical when n is zero.

Fig. 4 will fully illustrate the different types of curves for positive values of x; for negative values of x the curves may be either the images of the corresponding positive curves themselves, or of the reciprocals of the corresponding positive curves: the determination of their locus will depend upon the conventions adopted as to the fields of representation (as already indicated).

Fig. 3, curves 15 to 21, shews the curves e^{-nx} when $n = -0$ to $-\infty$ and x is positive, the line $y=0$ being the asymptote;

and in the same figure curves 15 and 22 to 27 shew the curves e^{+nx}, when $n = + 0$ to $+ \infty$.

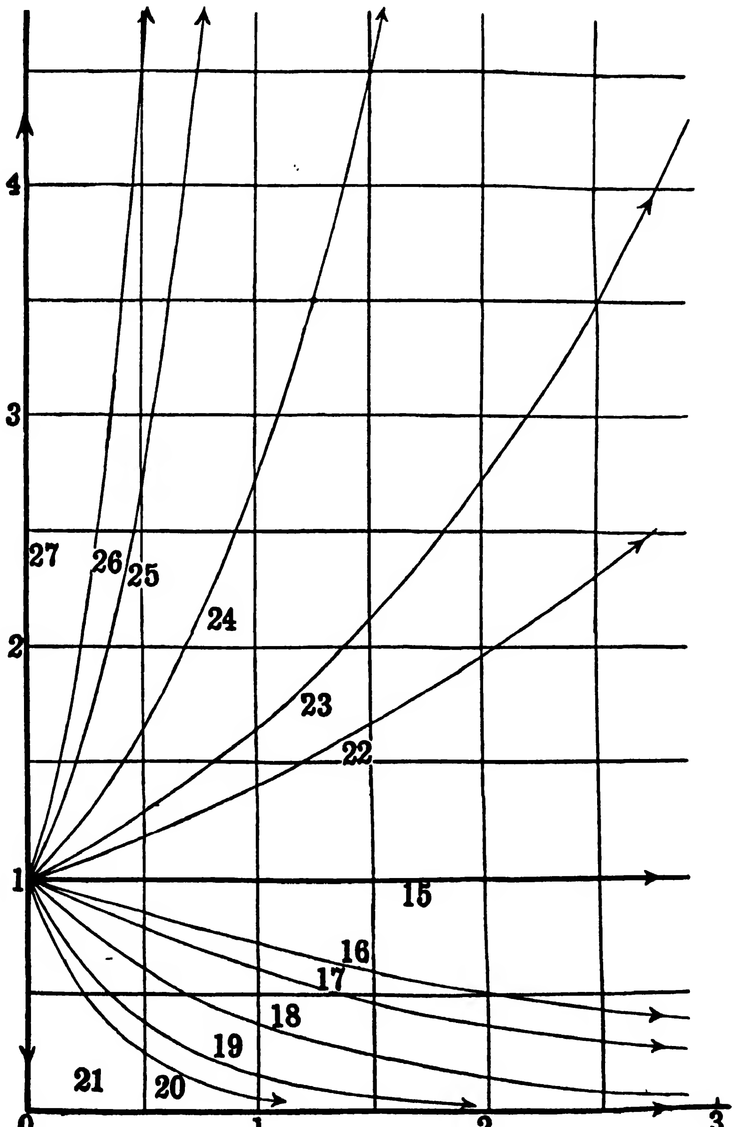


Fig. 3.

Fig. 4, shews (a) by medium continuous lines, curves 28 to 34, the curves e^{nx^p}, i.e. n, x and p are all positive: (b) by broken medium lines, curves 34′ to 40, the curves $e^{nx^{-p}}$, i.e. n and x positive, and p negative: (c) by thin continuous lines, curves 40′ to 46, the curves e^{-nx^p}, i.e. n negative and p positive; and by thin broken lines, curves 46′ to 52, the curves e^{-nx^p}, i.e. both n and p negative.

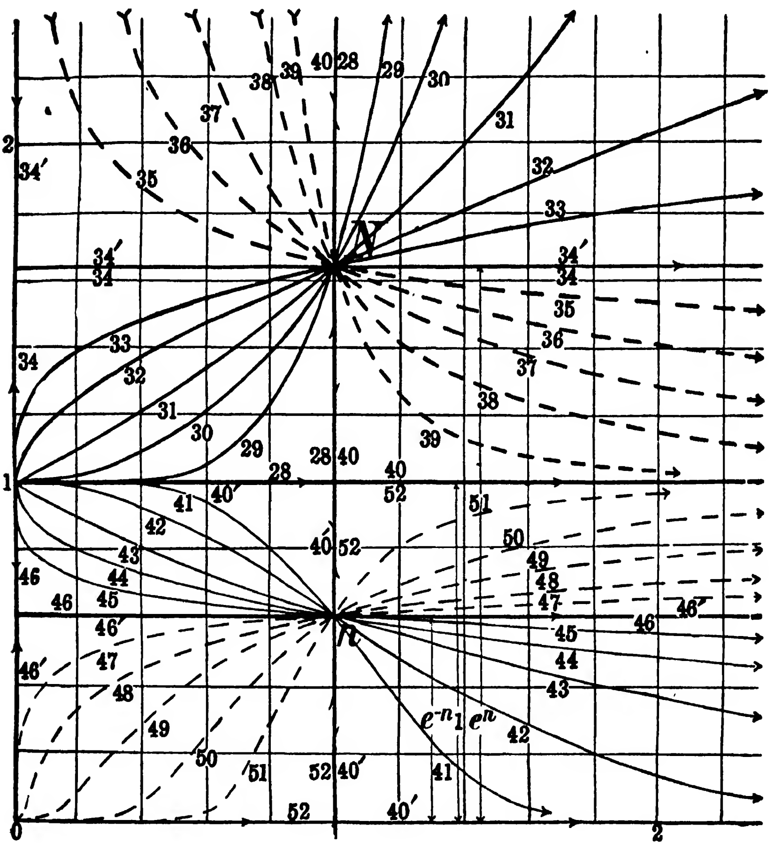


Fig. 4.

The curves actually shewn in Figs. 1, 2 and 3 are the following:—

Fig. 1 x^m No.	Value of m	Fig. 2, x^{-m} No.	Value of m	Fig. 3, e^{-nx} No.	Value of n	Fig. 3, e^{+nx} No.	Value of n
1	$+0$	8	-0	15	-0	15	$+0$
2	$\frac{1}{3}$	9	$\frac{1}{3}$	16	$\frac{1}{3}$	22	$\frac{1}{3}$
3	$\frac{1}{2}$	10	$\frac{1}{2}$	17	$\frac{1}{2}$	23	$\frac{1}{2}$
4	1	11	1	18	1	24	1
5	2	12	2	19	2	25	2
6	3	13	3	20	3	26	3
7	∞	14	∞	21	∞	27	∞

In Fig. 4, the curves are as follows:—

Curve $e^{\frac{1}{2}x^p}$ No.	Value of p	Curve $e^{\frac{1}{2}x^{-p}}$ No.	Value of p	Curve $e^{-\frac{1}{2}x^p}$ No.	Value of p	Curve $e^{-\frac{1}{2}x^{-p}}$ No.	Value of p
28	$+\infty$	34′	-0	40′	$+\infty$	46′	-0
29	4	35	$\frac{1}{4}$	41	4	47	$\frac{1}{4}$
30	2	36	$\frac{1}{2}$	42	2	48	$\frac{1}{2}$
31	1	37	1	43	1	49	1
32	$\frac{1}{2}$	38	2	44	$\frac{1}{2}$	50	2
33	$\frac{1}{4}$	39	4	45	$\frac{1}{4}$	51	4
34	0	40	∞	46	0	52	∞

Fig. 4a shews more clearly the limiting values for 0 and ∞, x being positive throughout, as follows:—

(i) Curves 28 to 34 n +; values of p $+\infty$ and $+0$.
(ii) Curves 34′ to 40 n +; -0 and $-\infty$.
(iii) Curves 40′ to 46 n −; $+\infty$ and $+0$.
(iv) Curves 46′ to 52 n −; -0 and $-\infty$.

3. Points of inflection of constituent curves.—The second derivative of x^m is $d^2y/dx^2 = m(m-1)x^{m-2}$; hence a point of inflexion can exist only if $x = 0$ and sign of the derivative changes.

The second derivative of the curve $y=e^{nx^p}$ is

$$d^2y/dx^2 = e^{nx^p}\{(npx^{p-1})^2 + np(p-1)x^{p-2}\} \quad\text{.........(9)}$$

so that putting this equal to zero, the points of inflexion are given by

$$x = \left(\frac{1-p}{np}\right)^{\frac{1}{p}} \quad\text{............(10)}$$

The conditions for points of inflexion, see Figs. 4, 4a and 4b are complex and may be stated as follows:—

A. *If* p *be positive*

In order that a point of inflexion may be between $x = 0$ and $x = 1$, $\frac{1-p}{np}$ must be > 0 and < 1

(a) *if* n *be also positive* (curves in heavy continuous lines), $1-p$ must be > 0 and $< np$

or p must be < 1 and $> 1/(n+1)$

(b) *if* n *be negative* (curves in thin continuous lines),

$1-p$ must be < 0 and $> np$

or p must be > 1 and $< 1/(n+1)$

B. *If* p *be negative.*

$1/\left(\frac{1-p}{np}\right)$ must be > 0 and < 1

i.e. $\frac{np}{1-p}$ must be > 0 and < 1

or np must be > 0 and $< 1-p$

(the signs of inequality will not change, since $1-p$ must be a positive quantity).

(a) *if* n *be positive* (curves in broken heavy lines), p must be > 0 (which is impossible as p is positive)

(b) *if* n *be negative* (curves in thin broken lines),

p must be < 0 and $1-p$ must be $> np$

or p must be < 0 and $p(n+1)$ must be < 1

Since p is negative the first condition is always fulfilled.

Since $p(n+1)$ must < 1

p must be $< 1/(n+1)$, if $n+1$ is positive, or if $n > -1$, and p must be $> 1/(n+1)$, if $n+1$ is negative, or if < -1.

It may be noted that if only the first mentioned of the conditions above specified be fulfilled in any of the particular cases (a), (b), there may be a positive point of inflexion. Fig. 4 illustrates the form of the curves, Fig. 4a their limiting positions, and Fig. 4b the inflexion-conditions in the respective regions.

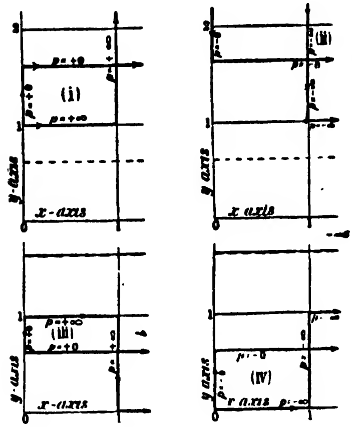


Fig. 4a.

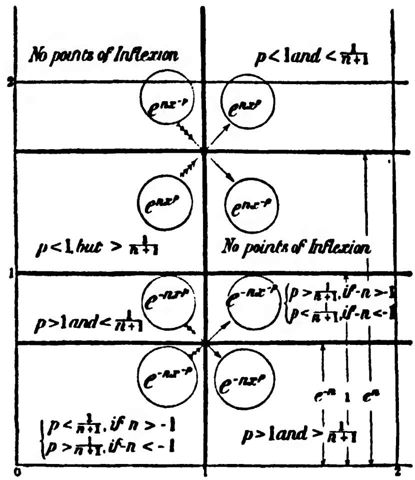


Fig. 4b.

4. Variety of the form of curve.—In order to give some idea of the variety of the form of the curve, and therefore its adaptability to statistical results, 16 cases have been traced and are shewn on Figs. 5 and 5a, and Figs. 6 and 6a. These values of m, n, and p for the several instances are as follows :—

Curves, $Ax^m e^{nx^p}$

	Fig. 5.			Fig. 5a.				
No. of curve	53	54	55	56	57	58	59	60
Value of m	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
Value of n	$-\frac{1}{2}$	$-\frac{1}{2}$	-1	-2	-1	$-\frac{1}{2}$	-1	-2
Value of p	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$	1	1	1	1	1

	Fig. 6.				Fig. 6a.			
No. of curve	61	62	63	64	65	66	67	68
Value of m	1	-6	6	6	-1	-6	1	1
Value of n	$-\frac{1}{4}$	$-\frac{1}{4}$	$-\frac{1}{4}$	$-\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{4}$	-1	-2
Value of p	6	-6	6	1	1	-1	1	1

Besides the above series of sixteen curves, the curves 1 to 52 may also be regarded as examples of degraded forms of the curve.

Fig. 5a.

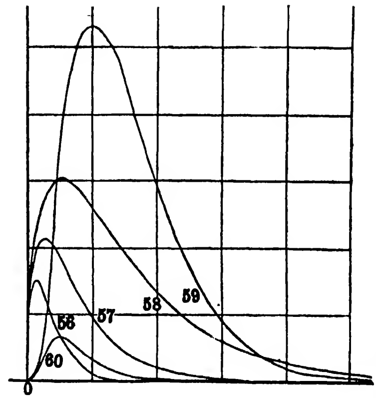
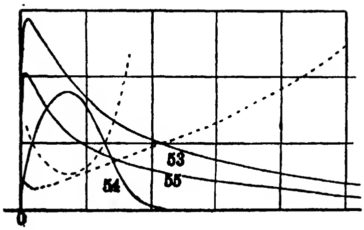
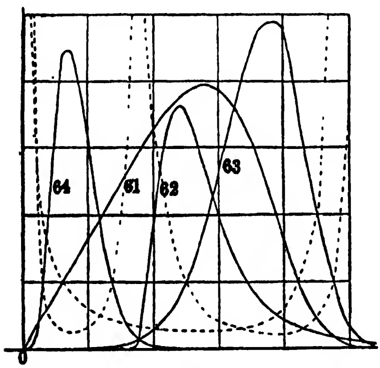


Fig. 5.





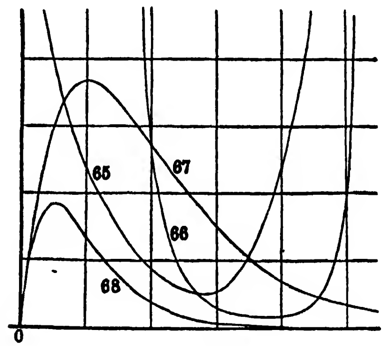


Fig. 6. Fig. 6a.

These may be scheduled as hereunder :—

Schedule of Forms for p positive.

Condition.	Expression		becomes	
$m=0$	n +, Exponentials[1]	$\exp(nx^p)$	n –, Exp. recip.	$1/\exp(nx^p)$
$n=0$	m +, Parabolas	x^m	m –, Hyperbolas	$1/x^m$
$m+$	n +,	$x^m \exp(nx^p)$	n –,	$x^m/\exp.(nx^p)$
$m-$	n +,	$\exp(nx^p)/x^m$	n –,	$1/\{x^m \exp(nx^p)\}$
$m=0$	p – 2, Error Curve[2]	e^{-nx^2}		

NOTE.—For p negative, write the division line between n and x throughout, thus n/x^p.

[1] $\exp(nx^p)$ denotes e^{nx^p}.

[2] n equals $1/k^2$ where k, or the modulus of x, is the reciprocal of what Gauss called the "measure of precision."

The curve takes on very closely such forms as are given by the following statistical equations:—

$y = A\ (1 + x/a)^{ma}\ (1 - x/b)^{mb}$, or its equivalent

$y = A\ (t/a)^{m}\ [(c-t)/(c-a)]^{n}$;

$y = A\ (1 - x^2/a^2)^{m}$

$y = A\ (1 + x/a)^{ma}\ e^{-mx}$

$y = A\ (1 + x^2/a^2)^{-m}\ e^{-n \tan^{-1} x/a}$

$y = A\ (x - a)^{m}\ x^{-n}$

and of course exactly expresses

$y = A\ x^{-m}\ e^{-n/x}$

$y = A\ e^{-x^2/k^2}$

5. Logarithmic homologue of curve.—The synthesis of the curve is brought into clearer light by examining its logarithmic homologue, viz. the curve the co-ordinates of which are the logarithms of the co-ordinates of the given curve.

Thus the nature of the products of the ordinates of the two generating curves can readily be seen by taking the logarithm of both sides of (1), thus:—

$$\log y = \log A + m \log x + nx^{p} \quad \text{............(11)}$$

thus with positive or negative values of both m and n, the numerical *sum* of the variable quantities is indicated; but the antilogarithm where the signs are negative is the reciprocal of the antilogarithm where the signs are positive.

Similarly if m be $+$ and n $-$, or *vice versa*, the numerical *difference* is indicated, the antilogarithm in the latter case being the reciprocal of the antilogarithm in the former.

The types of curves fully written out, included by the expression considered, are as shewn in the schedule above given. As m, n or p approach the values there indicated, the curve approaches that defined in the schedule, and the

curve may therefore be regarded as the limiting case in the particular direction.

6. Critical points of curves.—By successive differentiation, equations may be formed giving the critical points of the complete curve $y = x^m e^{nx^p}$.

For brevity, writing E for e^{nx^p} and P for npx^p, the successive derivatives, as far as the third inclusive, are:—

$$f(x) = x^m E \quad \text{............(11b)}$$

$$f'(x) = x^{m-1} E\,[m+P] \quad \text{............(12)}$$

$$f''(x) = x^{m-2} E\,[m(m-1)+P\{2m+p-1\}+P^2] \quad \text{......(13)}$$

$$f'''(x) = x^{m-3} E\,[m(m-1)(m-2)+P\{3m(m-1)+3m(p-1) +(p-1)(p-2)\}+P^2\{3m+3(p-1)\}+P^3] \quad \text{...(14)}$$

Thus from (12) the *maximum* or *minimum* value of y will be given by putting $f'(x)=0$, that is,—

$$m + npx_m^p = 0, \text{ or } x_m = (-m/np)^{\frac{1}{p}} \quad \text{.........(15)}$$

which when $p=1$, becomes

$$x_m = -m/n \quad \text{............(15a)}$$

x_m denoting the value of the abscissa for a maximum or minimum value of y.

When x has this particular value viz, that in (15), equation (13) reduces to

$$d^2y/dx^2 = -mp\,x^{m-2}\,e^{nx^p} \quad \text{............(16)}$$

which, when m and p are of the same sign, is negative; and when they are of opposite signs, positive. Hence from the criterion of convexity and concavity, for a maximum value, m and p must have the same sign, and for a minimum value opposite signs.

The points of inflexion occur when $d^2y/dx^2 = 0$, which we see from (13) occurs when

$$P^2 + P(2m + p-1) + m(m-1) = 0 \quad \text{............(17)}$$

The roots of this equation are

$$P = npx^p = \tfrac{1}{2}\{-(2m+p-1) \pm \sqrt{[(2m+p-1)^2 - 4m(m-1)]}\} \quad \text{...(18)}$$

from which, after reduction, we obtain

$$x_i = \left\{ -\frac{2m+p-1 \pm \sqrt{[4mp+(p-1)^2]}}{2np} \right\}^{\frac{1}{p}} \ldots\ldots(19)$$

x_i denoting the value of the abscissa for a point of inflexion.

The following values for the abscissæ of the maximum or minimum points and of the points of inflexion, with values of p from $\pm\frac{1}{2}$ to ± 3, will indicate some of the characteristics of the curve.

Positions of maxima or minima and inflexions.—

Value of p	Value of x_m	Values of abscissæ of inflexions x_i
-3	$(3n/m)^{\frac{1}{3}}$	$\{12n/[4m-8 \pm \sqrt{(64-48m)}]\}^{\frac{1}{3}}$
$2\frac{1}{2}$	$(2\frac{1}{2}n/m)^{\frac{2}{5}}$	$\{10n/[4m-7 \pm \sqrt{(49-40m)}]\}^{\frac{2}{5}}$
2	$(2\ n/m)^{\frac{1}{2}}$	$\{8n/[4m-6 \pm \sqrt{(36-32m)}]\}^{\frac{1}{2}}$
$1\frac{1}{2}$	$(1\frac{1}{2}n/m)^{\frac{2}{3}}$	$\{6n/[4m-5 \pm \sqrt{(25-24m)}]\}^{\frac{2}{3}}$
1	$(1\ n/m)^1$	$\{4n/[4m-4 \pm \sqrt{(16-16m)}]\}^1$
$\frac{1}{2}$	$(\frac{1}{2}n/m)^2$	$\{2n/[4m-3 \pm \sqrt{(9-8m)}]\}^2$
0	0	
$+\frac{1}{2}$	$(-2m/n)^2$	$\{-[4m-1 \pm \sqrt{(1+8m)}]/2n\}^2$
1	$(-1m/n)^1$	$\{-[4m \pm \sqrt{(0+16m)}]/4n\}^1$
$1\frac{1}{2}$	$(-\frac{2}{3}m/n)^{\frac{2}{3}}$	$\{-[4m+1 \pm \sqrt{(1+24m)}]/6n\}^{\frac{2}{3}}$
2	$(-\frac{1}{2}m/n)^{\frac{1}{2}}$	$\{-[4m+2 \pm \sqrt{(4+32m)}]/8n\}^{\frac{1}{2}}$
$2\frac{1}{2}$	$(-\frac{2}{5}m/n)^{\frac{2}{5}}$	$\{-[4m+3 \pm \sqrt{(9+40m)}]/10n\}^{\frac{2}{5}}$
3	$(-\frac{1}{3}m/n)^{\frac{1}{3}}$	$\{-[4m+4 \pm \sqrt{(16+48m)}]/12n\}^{\frac{1}{3}}$

The above expressions are left in their unreduced form in order to shew the progression of the quantities: that for $p = +1$ reduces to $-(m \pm \sqrt{m})/n$ indicating that the abscissæ of points of inflexion are equidistant from the abscissa of the maximum or minimum ordinate $-m/n$ by the distance $\sqrt{m}/n$, and that this condition is independent of the value of either m or n.

When p has any other value, we have, from (15) and (19), and after multiplying by $(2^{p+1}np)^{\frac{1}{p}}$

$$(-2^{p+1}m)^{\frac{1}{p}} = \{1-2m-p-\sqrt{[4mp+(p-1)^2]}\}^{\frac{1}{p}}$$
$$+\{1-2m-p+\sqrt{[4mp+(p-1)^2]}\}^{\frac{1}{p}} \ldots (20)$$

from which, when p is known, m can be so determined as to give the condition of equidistance of the points of inflexion from the maximum or minimum ordinate. This condition of equidistance is in all cases, independent of the value of n.

When $m=1$, equation (19), for the point of inflexion, gives

$$x = -\left(\frac{1+p}{np}\right)^{\frac{1}{p}}, \text{ or } 0,$$

and since when m has this value, that of the maximum ordinate is

$$x = -(1/np)^{\frac{1}{p}},$$

there is then no point of inflexion between the origin and the maximum.

With the ordinary algebraic conventions, if $4mp$ be negative and numerically greater than $(p-1)^2$, the points of inflexion are imaginary; and again if m and np have unlike signs the value of x for which $f(x)$ is a maximum or minimum, viz, $(-m/np)^{\frac{1}{p}}$, is in all cases real; but if m and np have like signs the value may be imaginary.

There are other points in the curve which may be important statistically, viz, those at which the tangent is changing its direction most rapidly. The points of inflexion are those at which the rates of increase of $f(x)$ are either algebraically greatest or least, and the maximum and minimum values of $f(x)$ are those at which the rates of increase are stationary. Hence the graph of $f'(x)$ is a curve crossing the axis of abscissæ at the values of x which give a maximum or a minimum, and has, for its abscissæ of its own maximum and minimum, those values of x which give the points of inflexion of the original curve. The abscissæ of the points of inflexion of the graph of $f'(x)$ are those of x

for which the rates of increase in the original function $f(x)$ are most or least rapidly increasing, and hence are those for which $f'''(x)=0$.

To determine these, we see from (14) that, writing as before $P=npx^p$, it is necessary to solve the cubic equation,

$$P^3+P^2\{3m+3(p-1)\}+P\{3m(m-1)+3m(p-1)+(p-1)(p-2)\}+m(m-1)(m-2)=0\ldots\ldots(21)$$

Putting $P=z-(m+p-1)$ equation (14) reduces to

$$z^3-z(2p^2-3p+3mp+1)+(p^3+2mp^2-2p^2+p)=0\ldots(22)$$

If $p=1$, equation (14) becomes

$$P^3+3mP^2-3m(m-1)P+m(m-1)(m-2)=0\ldots(23)$$

and (15) then becomes

$$z^3-3mz+2m=0\ldots\ldots\ldots(24).$$

7. Determination of constants of curve.—To find in the equation $y=Ax^m e^{nx^p}$ the constants A, m, n, and p, so as to reproduce a given curve from which, let us suppose, the values of y may be immediately obtained, recourse must be had to the analytic power of taking the logarithm of the quantities, a process by means of which products are resolved into sums, and exponential forms into products. Further than this it will be necessary also to utilise an operation which takes account of the fact that if a line be divided in a uniform *ratio*, its logarithmic equivalent will be divided into equal spaces. Thus if the points on a line, reckoned from the origin, be x, xq, xq^2, xq^3, etc., the logarithmic representation of these is $\log x$, $\log x+\log q$, $\log x+2\log q$, $\log x+3\log q$, etc. The solution is then as follows:—

$$\log y_r=\log A+m\log x_r+nx_r^p\ldots\ldots(25)$$

First to eliminate A, we have from this last equation

$$\log y_2-\log y_1=\log(y_2/y_1)=Y_{21}=m\log(x_2/x_1)+n(x_2^p-x_1^p)\ldots(26)$$

We take however four values of the abscissæ, so that $x_4/x_3=x_3/x_2=x_2/x_1$, so that if $x_2/x_1=q$, we shall have

$$x_2=qx_1,\ x_3=q^2x_1,\ x_4=q^3x_1,\ \text{etc.}\ldots\ldots(27)$$

To eliminate m and n we then proceed as follows:—
Omitting in x the suffix unity, which is the same throughout,

$$Y_{21} = m \log q + nx^p(q^p - 1) \ldots\ldots\ldots\ldots(26a)$$

$$Y_{32} = m \log q + nx^p q^p(q^p - 1) \ldots\ldots\ldots(26b)$$

the factor for Y_{43} being q^{2p} instead of q^p in the right-hand member. Hence

$$Y_{32} - Y_{21} = \log (y_1 y_3/y_2^2) = nx^p(q^p - 1)^2 \ldots\ldots(28)$$

Similarly

$$Y_{43} - Y_{32} = \log (y_2 y_4/y_3^2) = nx^p(q^p - 1)^2 q^p \ldots\ldots(28a)$$

Consequently,

$$(Y_{43} - Y_{32})/(Y_{32} - Y_{21}) = \{nx^p(q^p - 1)^2 q^p\} / \{nx^p(q^p - 1^2\} = q^p \ldots(29)$$

or

$$q^p = \frac{\log y_2 + \log y_4 - 2 \log y_3}{\log y_1 + \log y_3 - 2 \log y_2} \ldots\ldots(29a)$$

From this p may be found, since q is known. It is obvious that it is indifferent whether Naperian or common logarithms are used.

When p has been obtained, we have from (28)

$$n = \frac{\mu (\log y_1 + \log y_3 - 2 \log y_2)}{x^p(q^p - 1)^2}, \text{ or } \ldots\ldots(30)$$

$$n = \frac{\mu (\log y_2 + \log y_4 - 2 \log y_3)}{x^p q^p(q^p - 1)^2} \ldots\ldots\ldots\ldots(30a)$$

μ equals unity if Naperian logarithms are used, but if common logarithms are used, $\mu = 2{\cdot}3025850930$ approximately. Then n and p being known, m may be determined from (26a), which gives

$$m = \frac{\mu (\log y_2 - \log y_1) - nx^p(q^p - 1)}{\mu \log q} \ldots\ldots\ldots(31)$$

the same remark applying to μ as before. Then finally, using (25) we get

$$\log A = \log y_1 - m \log x_1 + Mnx^p \ldots\ldots(32)$$

in which $M = 1/\mu$ or $0{\cdot}4342944819$ approximately, if Briggsian (common) logarithms are used, or unity if Naperian logarithms are used.

This is the complete solution from four ordinates y_o being zero.

In selecting the four abscissae to obtain a solution of the constant, it is often necessary to locate two of them and determine the positions of the others therefrom. To do this q must be found from one of the following expressions

$$q = \sqrt[3]{(x_4/x_1)} = \sqrt{(x_4/x_2)} = \sqrt{(x_3/x_1)} = x_4/x_3 = x_3/x_2 = x_2/x_1 \text{ ......(33)}$$

Although for any four points, conditioned as indicated, the solution is unique, in general it is not sufficient to depend upon a single solution, however well the set of coordinates is selected. We may therefore take two or more sets (conforming to the condition of a constant ratio between the abscissae) and proceed as follows:—

For brevity writing equation (29a) in the form

$$q^p = Q \text{...........(29b)}$$

we shall have

$$p = \log Q / \log q \text{.........(34)}$$

It may be noted that the quantity Q is unaffected by changing the values of y in any constant ratio, for if y become ky the value of both numerator and denominator in (29a) remains unaltered. Calling the successive sets, each of which furnishes a complete solution, a, b, c, d, etc., the number of equations will be equal to the number of sets taken. These however will not in general be of equal weight.

The algorithm of computations with more than four ordinates will be referred to later, § 9.

8. Weight of results.—The complete solution of the weight of any result is as follows:—

We have from the theory of probability the weight, w, of any quantity is proportional to the reciprocal of the

square of the mean error, ϵ, or of the "probable error" ρ, etc.,[1]

$$w \propto 1/\epsilon^2 \propto 1/\rho^2 \text{ etc.}$$

The following fundamental equations may be derived from the theorem that to form the sum of quantities for which the signs + or — are equally probable, we must take the lines as vectors at right angles to each other.

Let the corresponding Greek letters α, β, γ, etc. denote the mean (or the probable) error of the quantities a, b, c, etc., then we shall have

$$(a \pm \alpha) + (b \pm \beta) = (a+b)\{1 \pm \sqrt{(\alpha^2+\beta^2)}/(a+b)\} \quad \text{......(35)}$$

$$(a \pm \alpha) \times (b \pm \beta) = ab\{1 \pm \sqrt{[(\alpha/a)^2 + (\beta/b)^2]}\} \quad \text{.........(36)}$$

$$(a \pm \alpha) \div (b \pm \beta) = \frac{a}{b}\left\{1 \pm \sqrt{[(\alpha/a)^2 + (\beta/b)^2]}\right\} \quad \text{......(37)}$$

$$(a \pm \alpha)^n = a^n\{1 \pm \sqrt{n}\,\alpha/a\} \quad \text{............................(38)}$$

$$\log(a \pm \alpha) = \log a \pm M\,\alpha/a \quad \text{............................(39)}$$

Let η, with a corresponding suffix, denote the mean (or the probable) error of any ordinate y. Then from (29a) we have, for the errors of the numerator and demominator, which latter for brevity may be respectively denoted by U and V, the value of (29a) fully expressed, viz.,

$$q^p = \frac{U \pm \sqrt{\{(\eta_2/y_2)^2+(\eta_4/y_4)^2+2(\eta_3/y_3)^2\}}}{V \pm \sqrt{\{(\eta_1/y_1)^2+(\eta_3/y_3)^2+2(\eta_2/y_2)^2\}}} = \text{...(40)}$$

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[1] The correlation of the various constants of the probability curve may be set out as follows:—

In terms of the symbol		Modulus k	Mean of errors m	"Mean error" ϵ	Probable error ρ
Modulus	k	1·000	0·564	0·707	0·477
Mean of errors	m	1·772	1·000	1·253	0·845
"Mean error"	ϵ	1·414	0·798	1·000	0·674
Probable error	ρ	2·097	1·183	1·483	1·000

A fundamental theorem connecting these parameters or constants with any derived quantities is as follows:—

If $a = pb + qc + rd +$ etc., then $k_a = \sqrt{(p^2k_b^2 + q^2k_c^2 + r^2k_d^2 + \text{etc.})}$, k_a denoting the modulus of a, k_b that of b, etc. Similarly in regard to any other parameter.

or

$$q^p = \frac{U}{V}\left\{1 \pm \sqrt{\left[\frac{\Sigma_{234}(\eta/y)^2}{U^2} + \frac{\Sigma_{123}(\eta/y)^2}{V^2}\right]}\right\} \text{......(40a)}$$

in which of course the suffixes to the sign of summation denote the suffixes for η and y written out as in (40).

If η/y be constant ratio throughout, r say, then (40) reduces to

$$q^p = \frac{U}{V}\left\{1 \pm 2r\sqrt{\left(\frac{1}{U^2} + \frac{1}{V^2}\right)}\right\} \text{......(41)}$$

But if η be the same quantity for each ordinate, s say, then

$$q^p = \frac{U}{V}\left\{1 \pm s\sqrt{\left\{\frac{\frac{1}{y_2^2} + \frac{2}{y_3^2} + \frac{1}{y_4^2}}{U^2} + \frac{\frac{1}{y_1^2} + \frac{2}{y_2^2} + \frac{1}{y_3^2}}{V^2}\right\}}\right\} \text{...(42)}$$

Thus, for convenience of computation, the former condition is to be preferred, and if it could be secured, the series of values of y for different values of q would be of equal weight whatever the absolute values of y.

The expressions for the error (40), (41) and (42) may be required in their absolute instead of their relative form: they are then the absolute probable errors of q^p, and for the three assumptions are:—

$$\eta_o = \pm\frac{1}{V^2}\sqrt{\{\Sigma_{123}(\eta/y)^2U^2 + \Sigma_{234}(\eta/y)^2V^2\}} \text{.........(43)}$$

$$r_o = \pm\frac{2r}{V^2}\sqrt{(U^2 + V^2)} \text{ ....(44)}$$

$$s_o = \pm\frac{s}{V^2}\sqrt{\left\{U^2\left(\frac{1}{y_2^2} + \frac{2}{y_3^2} + \frac{1}{y_4^2}\right) + V^2\left(\frac{1}{y_1^2} + \frac{2}{y_2^2} + \frac{1}{y_3^2}\right)\right\}} \text{...(45)}$$

Since the weight of any observation is proportional to the reciprocal of the square of its probable error, we have

$$w = 1/\rho^2 \text{..............(46)}$$

and the results for q^p will therefore have the following combining weights for the three instances considered, viz.

(i) where the probable error is peculiar to each ordinate,
(ii) when it is a constant ratio of the length of the ordinate
(iii) when it is the same absolute amount.

The combining weights for these three cases are:—

Case (i)...$w = 1/\eta_0^2 = V^4/\{\Sigma_{234}(\eta/y^2V^2) + \Sigma_{123}(\eta/y^2U^2)\}$ ......(47)

Case (ii)...$w = 1/r_0^2 = V^4/[4r^2(U^2 + V^2)]$ ....(48)

$$\text{Case (iii)}\ldots w = 1/s_0^2 = V^4\Big/\left[s^2\left\{U^2\left(\frac{1}{y_2^2} + \frac{2}{y_3^2} + \frac{1}{y_4^2}\right) + V^2\left(\frac{1}{y_1^2} + \frac{2}{y_2^2} + \frac{1}{y_3^2}\right)\right\}\right] \ldots(49)$$

Thus the most probable value of q^p is

$$q^p = \frac{w_1 \dfrac{U_1}{V_1} + w_2 \dfrac{U_2}{V_2} + \text{etc.}}{w_1 + w_2 + \text{etc.}} \ldots\ldots\ldots(50)$$

9. Algorithm of practical solution.—Statistical data of all kinds are however rarely of that degree of precision which would give significance to the computation p by the application of (50) and the earlier equations upon which it depends. Moreover it is questionable whether any curve actually traced so as to represent results actually furnished would conform to the fundamental expression, viz. (1), with sufficient exactitude. In practice it will ordinarily suffice therefore to see that the sum of the ordinates are of about the same order of magnitude, and then to calculate p from the geometrical mean without regard to their theoretical weights, thus:

$$q^{rp} = \Pi_1^r \frac{U}{V} \ldots\ldots\ldots\ldots\ldots\ldots(51)$$

where Π_1^r denotes the product of r values of U/V.

Since q has no error, the probable error of q^p immediately furnishes the probable error of p. Thus writing W for U/V, we have

$$q^p = W \pm \rho = W(1 \pm \rho/W) \ldots\ldots\ldots\ldots(52)$$

whence $M\, p = \log W/\log q \pm M\rho/W \log q$......(53)

M being unity or 0·434 etc. according as Naperian or common logarithms are used.

When the probable errors of q^p and p are found that for n can be determined, if required, from (30), that for m from

(31), and finally that for A from (32), and combinations could be made having regard to the weights.

Assuming that the sets of ordinates have been appropriately chosen so as to give each determination of p approximately equal weight, we may however, in practical computations proceed as follows:—

From (28) and (28a) we obtain

$$n = \log\left(\frac{y_1 y_4}{y_2 y_3}\right) / \{x^p (q^{2p} - 1)(q^p - 1)\} \text{.........}(54)$$

in which the values taken for q^p and p are those given by equation (51) furnishing a geometric mean value. But if there were r sets of values for the ordinates, we shall have r sets of equations like this last (54). Hence we have

$$n^r = \frac{\Pi_1^r (\log y_1 + \log y_4 - \log y_2 - \log y_3)}{\Pi_1^r \{x^p (q^{2p} - 1)(q^p - 1)\}} \text{.........}(55)$$

Π_1^r denoting as before the product of the r different values. In this equation, if y_1 be the same for each set, q alone being varied, we shall have $x^{rp}\Pi_1^r f(q)$ as the value for the denominator in this last expression; or if x_1 be varied, and q be kept constant, we shall have for the value of this denominator $f(q)\Pi_1^r(x)^p$.

When n has been found, there are three equations to determine m—see (26a) and (26b)—the third being for Y_{43}. They are not however independent. If we give double weight to the results dependent on y_2 and y_3 equation (26b) —the validity of assigning a higher weight is in most cases self evident—then we obtain

$$\log\left(\frac{y_3 y_4}{y_1 y_2}\right) = 4\,m \log q + Mnx^p (q^p - 1)(q^p + 1)^2 \text{...}(56)$$

which gives

$$m = \frac{\log\{(y_3 y_4)/(y_1 y_2)\} - Mnx^p (q^p - 1)(q^p + 1)^2}{4 \log q.} \text{...}(57)$$

Hence with r sets of values of y we have

$$m = \frac{\Sigma_1^r(\log y_3 + \log y_4) - \Sigma_1^r(\log y_1 + \log y_2) - Mn\Sigma_1^r\{x^p (q^p - 1)(q^p + 1)^2\}}{4\,\Sigma_1^r \log q.} \text{...}(58)$$

If x be varied, with q constant, we may write $Mn(q^p - 1)(q^p + 1)^2 \Sigma_1^r x^p$ instead of the final terms in the numerator and $4r \log q$ in the denominator. If x_1 be fixed for each set and q be varied, we shall have $Mnx^p \Sigma_1^r f(q)$, as the final term of the numerator.

When m, n, and p are found, we have $4r$ equations to determine A: thus (25) gives

$$\log A = \frac{1}{4r} \Sigma_1^r \log(y_1 y_2 y_3 y_4) - m\Sigma_1^r \{x(q^3+q^2+q+1)\}$$
$$- Mn\Sigma_1^r \{x^p(q^{3p}+q^{2p}+q^p+1)\} \ldots\ldots(59)$$

The actual computation of the constants A, m, n, and p is thus seen to be direct and tolerably simple.

10. Integral of the curve.—The indefinite integral

$$\int y dx = \int x^m e^{nx^p} dx \ldots\ldots\ldots(60)$$

will be required in several forms since it must, in general, be expressed in a series, and since also a form suitable when x is less than unity is ordinarily unsuitable when x is greater than unity.

Developing e^{nx^p} in a series by the exponential theorem, we obtain, on integrating term by term

$$\int y dx = \frac{x^{m+1}}{m+1}\left(1 + \frac{nx^p(m+1)}{(m+p+1)1!} + \ldots + \frac{n^r x^{rp}(m+1)}{(m+rp+1)r!} + \ldots\right) (61)$$

Otherwise, on putting $u = e^{nx^p}$, $v = x^{m+1}/m+1$ in order that $dv/dx = x^m$, and integrating by parts, the result is:—

$$\int y dx \frac{x^{m+1}}{m+1} e^{nx^p} - \frac{np}{m+1} \int x^{m+p} e^{nx^p} dx \ldots\ldots(62)$$

the continued application of which gives:—

$$\int y dx = \frac{x^{m+1}}{m+1} e^{nx^p} \left\{ 1 - \frac{npx^p}{m+p+1} + \frac{(npx^p)^2}{(m+p+1)(m+2p+1)} \right.$$
$$\left. + \frac{(-1)^r (npx^p)^r}{(m+p+1)\ldots(m+rp+1)} \pm \text{etc.} \right\} \ldots\ldots\ldots(63)$$

This last expression might also be derived from (61) by dividing the series in brackets by e^{nx^p} expressed as a series. Or again putting $nx^p = z$, so that

$$x = (z/n)^{\frac{1}{p}} \text{ and } dz/dx = npx^{p-} \text{ ....(64)}$$

we have

$$\int x^m e^{nx^p} dx = \frac{1}{n^{\frac{m+1}{p}} p} \int z^{\frac{m-p+1}{p}} e^z dz \text{.........(65)}$$

Hence writing μ for $(m-p+1)/p$ and integrating by parts, we have

$$\int z^\mu e^z dz = z^\mu e^z - \mu \int e^z z^{\mu-1} dz \text{.........(66)}$$

the continued application of which gives

$$\int z^\mu e^z dz = z^\mu e^z \left\{ 1 - \frac{\mu}{z} + \frac{\mu(\mu-1)}{z^2} - \ldots \right.$$
$$\left. + (-1)^r \frac{\mu(\mu-1)\ldots(\mu-r+1)}{z^r} \pm \text{etc.} \right\} \text{...(67)}$$

which, if $(m-p+1)/p$ be substituted for μ, takes the form

$$ydx = \frac{x^{m-p+1}}{np} e^{nx^p} \left\{ 1 - \frac{m-p+1}{npx^p} + \frac{(m-p+1)(m-2p+1)}{(npx^p)^2} - \right.$$
$$\left. \ldots + (-1)^r \frac{(m-p+1)\ldots(m-rp+1)}{(npx^p)^r} \pm \text{etc.} \right\} \text{...(68)}$$

The definite integral $\int ydx$ between the limits 0 and ∞ will often be required. When the index of the exponential factor is negative, the integration may be effected as follows:

If, as above, we put $\mu = (m-p+1)/p$, then $(m+1)/p = \mu + 1$, and if also we put $u = nx^p$ so that

$$dx/du = 1/(pn^{\frac{1}{p}} u^{\frac{p-1}{p}}) \text{.........(69)}$$

we have the result in the form of the second Eulerian integral, viz.:—

$$\int_0^\infty x^m e^{-nx^p} dx = \frac{1}{pn^{\mu+1}} \int e^{-u} u^\mu du = \frac{\Gamma(\mu+1)}{pn^{\mu+1}} =$$
$$\Gamma\left(\frac{m+1}{p}\right) \Big/ \left(pn^{\frac{m+1}{p}}\right) \text{.........(70)}$$

which gives also, by making $m = 0$,

$$\int_0^\infty e^{-nx^p} dx = \Gamma\left(\frac{1}{p}\right) \Big/ (pn^{\frac{1}{p}}) \text{ ....(71)}$$

11. Special cases of integration.—When $m = p - 1$ or $p = m + 1$ we have

$$\int x^{p-1}e^{nx^p}dx = npe^{nx^p} \text{ or } \int x^m e^{nx^{m+1}}dx = n(m+1)e^{nx^{m+1}} \quad (72)$$

as can be seen by differentiating the right-hand member, see (8) herein, or from (68) since $m-p+1$ is then zero.

When $m = 1-p$ or $p = 1-m$ we have from (61)

$$\int x^{1-p}e^{nx^p}dx = \frac{x^{2-p}}{2-p}\left\{1 + \frac{nx^p}{1!}\frac{(2-p)}{2} + \dots \right.$$

$$\left. + \frac{(nx^p)^r}{r!}\frac{(2-p)}{2+(r-1)p} + \text{etc.}\right\} \dots\dots\dots(73)$$

and from (63) the same integral is equal to

$$\frac{x^{2-p}}{2-p}e^{nx^p}\left\{1 - \frac{npx^p}{2} + \frac{(npx^p)^2}{2(2+p)} - \dots \right.$$

$$\left. + \frac{(-1)^r(npx^p)^r}{2(2+p)\dots\{2+(r-1)p\}} \pm \text{etc.}\right\} \dots(74)$$

When $m = -1$, the term e^{nx^p} may be expanded, the integration term by term then giving

$$\int e^{nx^p}\frac{dx}{x} = \log x + \frac{n}{1!}\frac{x^p}{p} + \frac{n^2}{2!}\frac{x^{2p}}{2p} + \dots + \frac{n^r}{r!}\frac{x^{rp}}{rp} + \text{etc}(75)$$

From (68) we also obtain

$$\int e^{nx^p}\frac{dx}{x} = \frac{e^{nx^p}}{npx^p}\left\{1 + \frac{1}{nx^p} + \frac{2!}{(nx^p)^2} + \dots + \frac{r!}{(nx^p)^r} + \text{etc}\right\} (75a)$$

In general, if the relation between m and p can be simply expressed, some simplification of the formulas will be found to facilitate computation.

12. Particular values of abscissa.—Several values of the abscissa besides those already referred to (viz: maximum, minimum, or mode, points of inflexion, points of most rapid change in direction of tangent, etc.) are required. The most important of these is the abscissa, x_c say, of the '*centroid vertical*'[1] i.e. *of the mean of the distribution.* This

[1] Since the function proposed for the determination of skewness is $(\chi_c - \chi_m)/\{\int[f(\chi)\chi^2 d\chi]/\int f(\chi)d\chi\}^{\frac{1}{2}}$ the ordinates χ being measured from the intersection of the centroid vertical with the axis. (See W. Palin Elderton's 'Frequency Curves and Correlation,' pp. 10, 11).

is equal to the sum of the products of each of the ordinates into its abscissa divided by the sum of the ordinates, that is

$$x_0 = \Sigma(xy)/\Sigma y = \int xf(x)dx/\int f(x)dx \text{......}(76)$$

This for the curve with the constants $+m$, $-n$, will be

$$x_0 = \frac{\int x^{m+1} e^{-nx^p}\, dx}{\int x^m e^{-nx^p}\, dx} = \frac{\dfrac{\Gamma(\frac{m+2}{p})}{pn^{\frac{m+2}{p}}}}{\dfrac{\Gamma(\frac{m+1}{p})}{pn^{\frac{m+1}{p}}}} = \frac{\Gamma(\frac{m+2}{p})}{\Gamma(\frac{m+1}{p})n^{\frac{1}{p}}} \text{......}(77)$$

A general formula for the computation of '*standard deviation*,' '*skewness*,' etc., will ordinarily be too complex to be of utility. Actual calculations can readily be made after (77) is numerically evaluated.

13. The constant A.—It is sometimes necessary or desirable to make the definite integral

$$A\int_0^\infty y dx = A\int_0^\infty x^m e^{-nx^p} dx = 1 \text{...........}(78)$$

In such a case therefore we must have, see (70),

$$A = pn^{\frac{m+1}{p}}/\Gamma\left(\frac{m+1}{p}\right) \text{..............}(79)$$

14. Approximate integration.—Ordinarily the value of the integral between limits can be found with sufficient accuracy from seven equidistant ordinates, since this would give an exact result if the curve were representable by an equation of the seventh degree, as has been shewn by the writer.[1] The necessary formula is:

$$A\int y dx = \frac{1}{840}\left\{41(y_1 + y_7) + 216(y_2 + y_6) + 27(y_3 + y_5) + 272y_4\right\}$$

which is very nearly given by[2] [...(80)

$$A\int y dx = \frac{1}{163}\left\{8(y_1 + y_7) + 42(y_2 + y\ ) + 5(y_3 + y_5) + 53y_4\right\} \quad (81)$$

The whole question of approximate integration by means of such formulæ (80, 81) will be dealt with in another paper.

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[1] This Journal, Vol. xxxiv, 1900, pp. 70–71.

[2] Formula (81) is much better than Weddle's rule.

The ANATOMY of the HEAD of the GREEN TURTLE *CHELONE MIDAS*, Latr.

Part I. The Skull.

By H. Leighton Kesteven, B.Sc., Lecturer in Physiology and Biochemistry, Technical College Sydney.

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[With Plates XX - XXXIII.]

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Within the limits of the sub-classes of the Reptilia there are striking variations in the skull, which in some cases do and in others do not involve rearrangement of the related soft structures, such variations are more marked when members of different subclasses are compared. It is proposed in this and subsequent contributions to examine and report upon variations in various reptilian forms. Since my objective is primarily comparative craniology of the Reptilia, it will be found that the skulls are described in detail, whilst the description of soft parts is confined mainly to such as may be expected to vary with the bony structures.

The present communication deals only with the skull, a description of the mandible and of the soft parts will follow in Part II. As far as I am aware, this is the first attempt to describe the skull of a reptile in detail. Throughout I have used purely anatomical terms to designate the various features described, and have as far as possible moulded these terms on the B.N.A. nomenclature of human anatomists.

The skull of *Chelone midas* or portions of it have been described by Owen (1), Huxley (2), W. K. Parker (3), Hoffmann (4), Hasse (5) and others. None of these descriptions pretend to completeness, nor taken together do they aggre-

gate a complete description. Previous statements as to the soft structures within the various canals, and all references to soft parts have been carefully verified, and in some cases corrected.

I have to express my thanks to Messrs. Hedley and McCulloch who collected the dried skull from which the separate bones were derived, to Mr. G. Liévain to whom I am indebted for material in the flesh, and to Acting Professor S. J. Johnston, whose kindness in placing the specimens and appliances of the Biological Department of the Sydney University at my disposal, has been of inestimable value to me.

THE SEPARATE BONES.

The PREMAXILLA *(Os praemaxillare)* [Figs. 1, 2, and 3] may be described as consisting of three plates, two in the same plane and continuous, the third nearly at right angles to this plane; the former are nasal plate *(lamina nasalis)* [1] above, and alveolar plate *(lamina alveolaris)* [2] below, the third is the palatine plate [3]. At the union of these three the bone is a good deal thickened, so that there is formed on the lateral aspect of the bone a maxillary surface *(facies maxillaris)* [4] for articulation with that bone, and a sagittal surface (*facies sagittalis*) [5] for articulation in the median sagittal plane with the other premaxillary bone. The upper surface (*facies nasalis*) [6] of the palatine plate enters into the formation of the nasal cavity, only the anterior portion of the inferior surface of this lamina shares in the formation of the palate (*facies palatina*) [7], the greater portion being covered by the vomer (*facies vomeralis*) [8].

The MAXILLA (*Os maxillare*) [Figs. 4 and 5] forming the major portion of the boundary of the mouth, and the lateral aspect of the face, consists of an alveolar plate (*lamina alveolaris*) [1], a flattened triangular prefrontal process

(*processus praefrontalis*)[2] and palatine process (*processus palatinus*) [3]. The alveolar plate, flattened from side to side, is of quadrilateral outline, its anterior margin (*margo praemaxillaris*) [4] articulates with the premaxilla. The posterior margin is bevelled at the expense of the outer table to form a squamous-suture surface for the jugal (*facies jugalis*) [5]. Superiorly this plate is flush with the outer surface of the prefrontal process in front, but further back its upper margin forms the lateral boundary of the floor of the orbit (*margo orbitalis*) [6]. The medial surface is covered by the palatine process above, and below this is sculptured by wide perpendicular grooves and intervening narrow ridges. The prefrontal process anteriorly forms the lateral boundary of the anterior narial aperture (*margo nasalis*) [7], behind it forms the lower half of the anterior boundary of the orbit (*margo orbitalis*) [8]. The medial surface supplies the lower half of the lateral wall of the nasal chamber (*facies nasalis*) [9], above this nasal surface is an area for articulation with the prefrontal (*facies praefrontalis*) [10]. The palatine process bears on its oral surface (*facies palatinus*) [11] a row of tooth-like conical tubercles on the crest of a longitudinal ridge (*agger masticatorius*) [12]. Above, the palatine process enters into the formation of the floor of the orbit (*facies orbitalis*) [13] in its posterior portion and the floor of the nasal chamber further forward (*facies nasalis*) [14]. The nasal and orbital surfaces are separated by a backward and medially projecting buttress of the prefrontal process, which for the greater part articulates with the nasal plate of the prefrontal, but in its lower portion presents a free prominent ridge, (*margo lacrymalis*) [15]. The medial edge of the palatine process articulates from before backwards with premaxilla [16], vomer [17] and palatine [18].

The PALATINE (*Os palatinum*) [Figs. 6, 7, and 8] consists of an irregularly rhomboidal, flat, stout plate of bone [1],

bearing a more expansive but lighter orbital plate [2] dorsally. The ventral surface [3] flush with the rest of the palate bones is like them deeply pitted. The antero-medial margin [4] articulates with the vomer, the antero-lateral [5] with the maxilla, the postero-lateral [6] with the pterygoid process of the jugal, whilst the postero-medial margin [7] forms the greater part of the arcuate margin of the palate bounding the naso-palatine fossa [68, fig. 47]. The dorsal surface is divided by the attachment of the orbital plate into an anterior and medial nasal surface [8] and a posterior orbital surface [9]. The orbital plate extends upward and medially to articulate with the vomer and its fellow of the other side (*margo sagittalis*) [10] roofing the posterior nasal passage and forming portion of the floor of the orbit, there is thus formed between the two plates a deep nasal sulcus [11]. The posterior margin articulates with the pterygoid [12], the anterior margin is free and forms the posterior margin of the lachrymal foramen [13].

The VOMER [Figs. 9, 10, 11, and 12] consists of a vertically placed body [1] bearing palatine [2], prefrontal [3] and pterygoid [4] processes. The body is interposed between the two posterior narial passages, stouter in front than behind, it bears above the prefrontal processes, and between these is deeply grooved (*sulcus ethmoidalis*) [5]. Behind the ethmoidal sulcus the upper surface of the body forms a median strip of the floor of the orbits (*facies orbitalis*) [6]. The palatine process is a horizontally expanded plate of bone, about twice as long as broad, its palatine surface is strongly concave in both directions [13]. It forms a broad central area of the palate, articulates in front with the premaxillae [7], and laterally with maxillae [8] and palatines [14], and forms the median segment of the arcuate margin of the palate [9]. The conical prefrontal

processes are received into sockets in the nasal plates of the prefrontal bones. The pterygoid process is an elongated plate of bone which projects backwards from the dorsal portion of the posterior end of the body, anteriorly the process is flattened from side to side, but further back is flattened from above down. The orbital laminae of the palatines articulate with the edges of the body dorsally, and cover the whole of the superior aspect (*facies tecta*) of the pterygoid process [10]. The ventral surface forms the median portion of the naso-palatine fossa [11]. Posteriorly the process articulates with the pterygoid [12].

The PREFRONTAL (*Os praefrontale*) [Figure 13] lodging the superior recess of the nasal cavity [3] and forming the anterior wall of the orbit [see fig. 46] consists of a stout body [1] and a twisted nasal plate [2]. The body as seen from above is of irregularly hexagonal outline. The anterior border [4] forms the dorsal boundary of the anterior narial aperture. The medial margin (*margo sagittalis*) [5] articulates with the opposite prefrontal. The frontal margin [6] presents medial and lateral segments forming an angle with one another. The orbital margin forms the upper part of the anterior boundary of the orbit [see fig. 45]. The maxillary margin [7] confluent with the outer edge of the nasal plate forms with it an area for articulation with the prefrontal process of the maxilla. The attachment of the nasal plate crosses the inferior surface of the body from the hinder end of the sagittal to the junction of orbital and maxillary margins, laterally it is much thickened and is deflected forward to the junction of maxillary and nasal margins of the body. Behind the attachment of the nasal plate the body forms the anterior po rton of the roof of the orbit, the whole orbital surface of the bone being evenly rounded [see fig. 46]. The medial margin [8] of the nasal process bounds the ethmoidal fissure, its inferior margin

supplies the anterior boundary of the lachrymal foramen (*margo lacrymalis*), at the angle between these two is the socket-like notch with which the prefrontal process of the vomer articulates (*incisura vomeralis*) [9].

The FRONTAL (*Os frontale*) [Fig. 14] is a stout flat bone of irregularly pentagonal outline. On the inferior surface a longitudinal ridge (*crista orbito-sphenoidea*) [1] separates a narrow medial area (*semisulcus olfactorius*) [2] from an expansive orbital surface [3]. With the bones in contact the two olfactory semisulci form the roof of that portion of the cranial cavity which lodges the olfactory peduncles, the orbito-sphenoid cartilages are attached to the ridges of that name. The medial border (*margo sagittalis*) [4] articulates with the other frontal. The bone also presents parietal [5], post frontal [6] and prefrontal [7] margins for articulation with those bones, and between the last two it shares in the formation of the boundary of the orbit [8].

The PARIETAL (*Os parietale*) [Figs. 15 and 16] consists of an oblong flattened body [1] bearing below a downwardly projecting alisphenoid plate [2]. The ventral surface is divided by the base of the alisphenoid plate and the orbito-sphenoid crest [3] into narrow cerebral [4] and a very much more extensive orbito-temporal area. The anterior portion of the cerebral surface is a backward continuation of the olfactory semisulcus on the frontal, and the orbito-sphenoid crest which limits it, is continuous with that of the same bone. The orbito-temporal area is divided into a lachrymal surface in front [5] in contact with the lachrymal gland, and a temporal surface [6] behind, by a low rounded ridge which, though at times slightly developed, can always be detected. The body articulates with the other parietal along the sagittal margin [7]. Behind the cerebral surface, which only extends along one half the bone, is an area for articulation with the supraoccipital; this supraoccipital surface

[8] is continued up the medial aspect of the hinder border of the alisphenoid plate. The posterior margin of the body is free and forms the posterior boundary of the false roof (*margo temporalis*) [15], the lateral border is divided into squamosal [9] and postfrontal [10] segments, anteriorly the bone articulates with the frontal [11]. The alisphenoid process is a triangular plate of bone, its anterior margin merges above with the orbito-sphenoid crest. The apex articulates with the epipterygoid process of the pterygoid bone being deeply notched to receive that process (*incisura pterygoidea*) [13]. The free portion of the posterior margin bounds the foramen ovale [14], and above this is a small facet which articulates with the prootic (*facies prootica*) [12].

The POSTFRONTAL (*Os postfrontal*) [Fig. 17] presents frontal [1], parietal [2], squamosal [3], quadrato-jugal [4], and jugal [5] borders for articulation with those bones, and by an arcuate orbital margin [6] it bounds the postero-superior one third of the orbit. Continued up and slightly backwards from the vertical segment of the orbital margin is a rounded ridge which divides the inner surface into lachrymal [7] and temporal surfaces [8], the one in contact with the lachrymal gland and the other walling in the temporal fossa.

The JUGAL (*Os jugale*) [Fig. 18 and 19], of irregular form, presents margins for articulation with postfrontal [1] quadrato-jugal [2] and maxilla [3]. Its anterior margin [4] bounds the postero-inferior segment of the orbit, and opposite this is a free border which forms the anterior margin of the zygomatic sinus (*margo zygomatica*) [5]. Anteriorly the body bears a medially projecting plate of bone (*processus pterygoideus*) [6] which is the homologue of the ectopterygoid, and like that bone serves to connect the maxilla and pterygoid [9], there is however no gap between it and the

palate, since by its anterior margin it articulates with both maxilla [7] and palate bone [8] (5 figure 47).

The QUADRATO-JUGAL (*Os quadrato-jugale*) [Fig. 20] a flat plate of bone of irregular crescentic outline, presents margins for articulation with jugal [1], postfrontal [2], squamosal [3] and quadrate bones, and also a margin [7] forming a large portion of the boundary of the zygomatic sinus. The margin of articulation with the quadrate is arcuate above (*margo tympanicus*) [4] where it bounds the tympanic fossa in that bone, and below this is straight (*margo suspensoria*) [5] articulating with the suspensory ramus of the quadrate. At the junction of the two segments, is a prominent sharp infratympanic spine [6].

The SQUAMOSAL (*Os squamosale*) [Fig. 21] though a flat bone, is particularly stout and quite belies its name, of irregular shape it presents two surfaces and six borders. The postero inferior border [1] forms the outer lip of a sulcus which lodges the outer head of the squamoso-maxillaris muscle (*sulcus squamoso-maxillaris lateralis*)[2]. Above this border the temporal margin [4] makes, in the articulated skull, a slight angle with the temporal margin of the parietal, and like it forms the posterior margin of the roof of the temporal fossa. The superior margin [5] articulates with the parietal, in front of this margin is that [6] for articulation with the post frontal, and making a sharp angle with this last is a short quadrato-jugal margin [7]. The bone also articulates with the parotic ramus of the quadrate by a deeply concave margin (*margo tympanicus*) [8] bounding the tympanic fossa behind, and a fairly extensive area (*facies quadrata*) [9] on the inferior surface of the parotic process. This last (*processus paroticus*) [70 fig. 43] is a three sided pyramidal mass attached to the inner side of the bone in the postero-inferior region. The process is evenly rounded above, beneath it articulates with

the quadrate, and posteriorly presents two sulci, [71 and 72, fig. 43] the outer of these has been mentioned above, the inner is much smaller, it gives attachment to the inner head of the squamoso-maxillaris muscle (*sulcus sm.-q. medialis*) [3]. The apex of the process articulates with the opisthotic (*facies opisthotic*) [10].

The Basioccipital (*Os occiptale basilare*) [fig. 22] is composed of three short stout rami attached to a quadrate body. A triangular area on the upper surface of the body shares in forming the floor of the cranial cavity (*facies cerebralis*) [1]. The anterior angles of the triangular cerebral surface are truncated by a bevelling of the bone where it shares in bounding the auditory capsule (*facies otica*) [2]. Between these there is an oval tubercle [3] which gives attachment to the bifid ligament of the medulla. Lateral to and behind cerebral and otic surfaces the upper surface of the body is flush with the sloping upper surfaces of the paroccipital [4] and condylar [5] rami, the whole area thus formed on either side articulates with the exoccipital [6]. Anteriorly the body articulates by synchondryosis with the basisphenoid. The paroccipital rami spring from the body on either side ventrally. Anteriorly each presents a pterygoid surface for articulation with the basitympanic portion of that bone, and beneath these is an arcuate area for articulation with the upper surface of the basipterygoid processes of the basisphenoid. The condylar facet [7] occupies the end and a small area on upper and lower surfaces of the condylar ramus. On the posterior aspect of each paroccipital ramus is a smooth surface which is continued a little way along the lateral surface of the condylar ramus, this arcuate surface [8] forms the lower half of the paroccipital fossa [61, fig. 43].

The Exoccipital (*Os occipitale laterale*) [Figs. 23, 24, and 25] consists of a stout body [1] bearing condylar [2]

paroccipital [3], parotic [4], and supra-occipital [5] rami. The body is a short stout triangular bar of bone from which condylar and paroccipital rami spring inferiorly, the former extending backwards, the latter laterally, from the upper end the supraoccipital ramus extends medially, the parotic laterally and downwards. The three surfaces of the body are cerebral [fig. 49] acustico-jugular [6] and external [7]. The hypoglossal canals [8] perforate the body, from cerebral to external surfaces. Inferiorly the surface for articulation with the basioccipital extends over the whole of this aspect of condylar and paroccipital rami [9]. Laterally this last ramus articulates with the pterygoid [10]. The parotic ramus articulates with the opisthotic, this opisthotic surface [11] is on the anterior aspect of the ramus, and is not defined from the supraoccipital surface [12] on the antero-superior margin of the supraoccipital ramus. Below the external apertures of the hypoglossal canals the curved surface [13] common to condylar and paroccipital rami forms the upper half of the paroccipital fossa in the articulated skull. The condylar facet [14], extends round somewhat on to the side of the condylar ramus.

The SUPRAOCCIPITAL (*Os occipitale superius*) [Figs. 26 and 27] is an arch-like bone, with a remarkably large laterally compressed plate of bone [1] standing up and back from the centre of the arch. The surface [2] for articulation with the parietals occupies the whole of the dorsal edge of the crest, and extends down the lateral aspect of the bone along the anterior border. The plates forming the arch are thickened below in the region where the epiotic bones have become incorporated with them (*pars epiotica*) [3]. The free margin of the epiotic portion articulates, by synchondrosis, with the prootic in front [4] and the opisthotic behind [5]. From the inner side of this margin in the middle of its length a small plate of bone

(*lamina epiotica*) [6] stands down and medially beyond the general contour [57, fig. 49], this lodges the lower arm of a three rayed sulcus (*sulcus vestibularis epioticus*) [7] which in the recent state is converted by cartilage into the epiotic vestibular recess. Behind the opisthotic there is on each lamina an articular surface [8] for the supraoccipital ramus of the exoccipital.

The Opisthotic (*Os opisthoticum*) [Figs. 28 and 29] is a wedge shaped bone, which in the articulated skull is interposed obliquely between the exoccipital and the quadrate. The oval exoccipital surface [1] occupies the greater part of the postero-inferior aspect of the bone, the somewhat larger quadrate surface occupies nearly the whole of the antero-superior surface. Superiorly the bone shares in forming the floor of the temporal fossa; inferiorly [2] it forms portion of the roof of the acustico-jugular cavity. The outer end of the inferior surface, just where it forms the angle with the vertical outer margin of the bone generally presents a more or less well marked tubercle (*tuberculum capiti-plastralis*) [3] to which the main portion of the tendon of the capiti-plastralis muscle is attached. The inner end of the bones presents surfaces for articulation with the supraoccipital [4] and prootic bones [5]. It is also excavated to form the opisthotic vestibular recess (*recessus vestibularis opisthoticus*) [6] with which the posterior vertical [7] and horizontal [8] semicircular canals communicate. Immediately below the recess, the bone is perforated by the glossopharyngeal canal [9]. A small flat tongue of bone extends down from the body just below and in front of this last canal, this interfenestral process [10] forms with the body the boundary of a well marked though small notch [11] behind, the upper half of the fenestra rotunda, which in the recent state is completed by cartilage.

The Prootic (*Os prooticum*) [Fig. 30] of very irregular shape articulates with quadrate, pterygoid, basisphenoid,

supraoccipital [7] and opisthotic [8]. Posteriorly it is excavated to form the prootic vestibular recess [1], with which the anterior semicircular [2] canal communicates above and the horizontal laterally. The medial wall of the horizontal canal being formed entirely by the opisthotic, the canal is here represented by a sinus only (*sinus canalis inferior*) [3]. The medial wall of the recess is perforated by the anterior cribrose foramen [4] which transmits the vestibular branch of the auditory nerve. Viewed from the medial aspect [fig. 49], this foramen [55, fig. 19] is found in the bottom of a fossa whose posterior wall is rendered imperfect by a small sharp notch, [9] (54, fig. 49) this latter is completed by cartilage, forming the posterior cribrose foramen which transmits the cochlea branch of the nerve. The fossa is the internal auditory meatus and is perforated also by the facial canal [5] (36, fig. 49). Immediately below the auditory meatus the bone articulates with the basisphenoid. Lateral to the basisphenoid surface [6] the bone is grooved by the issuing facial nerve, and presents a fairly wide sulcus, whose outer boundary is the ridge which articulates with the prootic process of the pterygoid, this sulcus forms the roof of the jugular canal. There are two areas for articulation with the quadrate, of which the posterior is very much the smaller, between them the bone forms the medial wall of the temporal sinus and foramen. Behind the region of the jugular canal the inferior surface of the bone forms the roof of the jugular sinus.

The QUADRATE (*Os quadratum*) [Figs. 31 – 35], a very massive bone, is most conveniently described as consisting of two stout rami united together along the anterior half of their length, and diverging from one another at an acute angle posteriorly. The upper limb [A] (*ramus oticus*) bears on the medial aspect an oval area [1], which extends along the length of the dorsal margin, for articulation with the

opisthotic. Anteriorly the lower limb [B] (*ramus suspensorius*) bears on the same aspect a very similar area [2] for articulation with the pterygoid. Between the opisthotic and pterygoid surfaces the conjoined rami form the lateral wall and portions of floor and roof of the acustico-jugular cavity. This area is impressed in front by a broad curved sulcus (*sulcus temporo-jugularis*) [3]. At the upper end of this the medial border of the temporo-zygomatic surface is deeply notched (*incisura temporalis*) [4]. With the prootic and pterygoid bones in position this sulcus is converted into the temporal canal above and jugular sinus below. In front of the sulcus is an area [5] which articulates with the larger quadrate surface on the prootic, the smaller quadrate surface on that bone articulating with the spur which bounds the temporal notch posteriorly. The pterygoid surface is continued along the inner surface of the pedicle [6] which latter also articulates, synchondrotically, by its apex with the epipterygoid. Below the pterygoid surface the suspensory ramus presents a smooth concave area (*facies pterygo-mandibularis*) [9] from which portion of the pterygo-mandibularis muscle arises. Forming the anterior and inferior boundary of this area and continued along the pedicle is a prominent sharp margin which separates it from the antero-inferior surface of the ramus, this last, concave from side to side, is continued round without interruption on to the superior aspect of the otic ramus. The whole of the temporo-zygomatic surface [8] so formed gives attachment to muscles of mastication or has those muscles playing over it. The continuation of this surface backwards is covered by the parotic process of the squamosal. The greater portion of the area so covered takes the form of a raised quadrangular facet [9]. Behind this facet is that aspect of the otic ramus which forms the roof [10] of the notch between the two rami (*incisura post-tympanica*). The suspensory ramus bears the condyle, above this posteriorly

is a smooth concave surface (*facies trochlearis*) [11] over which the squamoso-mandibularis muscle works, above this again is that aspect of the suspensory ramus which forms the floor [12] of the post-tympanic notch. In the depth of the notch is a well defined groove (*sulcus columellae auris*) [13] which is converted by a membrane into the columella canal, and lodges the columellae auris. Turning now to the lateral aspect of the bone, it is seen that the flange which forms the outer portion of the temporo zygomatic surface for the greater part of its length, forms also the lower and anterior wall of a large oval tympanic fossa [14] of which the upper portion is excavated out of the otic ramus. The post-tympanic notch extends so far into the fossa that the outer end of the columella sulcus is almost in its centre. At the postero-inferior angle of the otic ramus, there is commonly developed a tubercle (*tuberculum post-tympanicum*) [15] for the attachment of the tough membrane which completes the fossa across the notch. The condyle [16] is elongated from side to side and concave from before backwards. In the middle of its length it is narrowed and here presents a broad groove transverse to the long axis.

The otic and suspensory rami and pedicle are completely homologous with those three portions of the amphibian suspensorium.

The PTERYGOID (*Os pterygoideum*) [Figs. 36 and 37] an elongated flattened bone, may be conveniently divided for descriptive purposes into an anterior pharyngeal portion A parallel to the longitudinal axis and a posterior stouter portion B (*pars basitympanica*) diverging from that axis. The pharyngeal portion forms with its fellow a bony roof to the pharynx immediately behind the nasopalatine fossa and between the two zygomatic fossae, its anterior margin articulates with vomer [1], palatine [2], and pterygoid pro-

cess of jugal [3]. An area [4] along the sagittal margin [5] of the upper surface for articulation with the basisphenoid, is continued backwards on to the basitympanic portion of the bone. The remainder of the upper surface of the pharyngeal portion is divided by the base of the epipterygoid process [6] into narrow jugular [7] and extensive orbital [8] surfaces. The epipterygoid process is a triangular plate of bone, whose base crossing the pharyngeal portion obliquely from before backwards and laterally reaches the anterior limit of the basitympanic portion. Behind this process and placed more laterally upon the upper surface of the basitympanic portion is the much smaller prootic process [24]. Medial to the last is a deep and wide jugular sulcus [9]. The medial wall of the jugular sulcus is the outer side of a raised trangular surface for articulation with prootic [10] and basisphenoid [11] bones. Medially this raised area overhangs the anterior aperture of the carotid canal [23] whereby a short sulcus [12] is formed, which is converted into a canal in the articulated skull by the basiphenoid bone. Immediately to the inside of the carotid sulcus is another small area [13] for articulation with the basisphenoid. The remaining portion of the upper surface of the basitympanic portion of the bone forms part of the floor of the acustico-jugular cavity [14]. The whole lateral edge of this part of the bone [15] articulates with the quadrate. The posterior aperture of the carotid canal [16] is flanked medially by a flattened paroccipital lamina, [17] which shares in the formation of the paroccipital process. The paroccipital rami of exoccipital and basioccipital which complete that process articulate with the medial surface of the bone, the two articular areas [18 and 19] being quite distinct. Springing from the lateral aspect of the epipterygoid process and extending back and ventrally towards the quadrate surface of the basitympanic portion, is a flange of bone (*crista pedicularis*) [20] which overhang-

ing the pharyngeal portion of the bone forms with it a wide sulcus (*sulcus pterygo-mandibularis*) [21]. The epipterygoid [22] articulates with the epipterygoid process laterally so as to continue the pedicular crest, with which the pedicle of the quadrate articulates.

The EPIPTERYGOID (*Os epipterygoideum*) [22 fig. 36) is a relatively very small rod of bone of triangular cross section, articulating by one face with the epipterygoid process of the pterygoid, and by its upper end with the alisphenoid plate of the parietal; these two articulations are true sutures. Inferiorly ossification of the cartilage between it and the pedicle of the quadrate has never been completed and a more or less extensive gap occurs between the bones in the macerated skull.

The BASISPHENOID (*Os basiphenoideum*) [Figs. 38 and 39] consists of a quadrangular body [A], elongated tapering rostrum [B], and paired basipterygoid process [C]. The anterior limit of the body is an imaginary line drawn between the two postclinoid processes. The upper surface of the body is deeply concave in both directions, (*fossa medullaris*). The postclinoid processes [1] are triangular plates of bone, set on either side of the anterior margin of the medullary fossa and overhanging the "*pars sellae*" [2] of the rostrum. The base of each postclinoid process is perforated by the abducent canal [3]. One each side behind the base of the postclinoid process is an area [4] for articulation with the prootic. Posteriorly [5] the body forms a synchondrotic union with the basioccipital. In the mid line the transverse occipital margin is raised to form the anterior portion of the ovoid tubercle [6], whose major part is situated at the transverse basiphenoid margin of the cerebral surface of the basioccipital. Between the occipital and prootic surfaces the postero-lateral angles of the body are beveled away to form a small otic surface [7]. The

basipterygoid processes are peculiar in that springing from the under surface of the body they are directed *backwards* and laterally, they are very broad at their base and together form a triangular area, which in the articulated skull appears between the diverging basitympanic portions of the pterygoids and the basioccipital. The basioccipital articulates with a narrow crescentic area [5] on the upper surface of the arcuate posterior margin of the processes, below this a free surface [9] on the conjoined processes forms with the basioccipital in the articulated skull an arcuate fossa into the sharp margin of which the occipital tendons of the dorso-occipital muscles are inserted. Between the processes and the body on either side is a deep notch into which the pterygoid bones fit [11]. The rostrum is perforated on either side in front of the pituitary region by a carotid foramen [10], the two foramina opening close together on either of the mid line, on the dorsal aspect just a little further forward, are continued anteriorly as grooves on this surface of the bone. Inferiorly the rostrum articulates with the pterygoid bones and is from this aspect entirely hidden by them.

The Entire Skull.

(A) Preliminary review [Figs. 40 to 50].

As viewed from above, the side, and in front the following features are seen. The sagittal suture is continued right forward to the alveolar margin, being only interrupted by the anterior nasal aperture. The bones on either side of the sagittal suture are, from before backwards, the premaxillae, prefrontals, frontals, and parietals (P. Mx., P. Fr., Fr., Par.). The premaxillae form the most anterior portion of the alveolar margin, which is completed on either side by the maxillae (Mx.), posteriorly the maxillae articulate with the jugals (Ju.) and these with the quadratojugals (Q.J.), which in turn articulate posteriorly with the

quadrates (Qu.). These last two bones are not continued back in the line of the alveolus but arch upwards and outwards, over a broad notch *(sinus zygomaticus)* [69] through which the muscles of mastication pass down and back to the mandible. The prefrontal process [1] of the maxilla serves to connect that bone with the prefrontal. The jugal articulates above with the postfrontal, and this by its medial border with the frontal in front and parietal behind. The squamosal (sq.) is fitted in between the quadrate and quadrato-jugal below, the postfrontal anteriorly and the parietal medially.

Basal view.—The palatine processes [2] of the premaxillae, besides articulating laterally with those of the maxillae [3], articulate with the palatine plate of the vomer [4] behind them. Laterally this plate of the vomer articulates with the palatine processes of the maxillae, but further back the palatines intervene between these two structures. The posterior border of the bony palate on either side is formed by the pterygoid process of the jugal [5]. The pterygoid process of the vomer [6] articulates with the pharyngeal portion of the pterygoid bones [7] behind it, whilst laterally it articulates with the orbital plates of the palatines [8], these latter articulate with the same portions of the pterygoid bones on either side of the vomerine process. The basitympanic portions [9] of the pterygoid bones extending backwards and outwards, expose between their diverging medial borders the inferior surfaces of the basipterygoid processes [10] of the basisphenoid; laterally these portions of the pterygoids articulate with the suspensory rami [11] of the quadrate bones (Qu.), whilst beyond the basisphenoid each extends back to enter into the formation of the paroccipital process [12], bearing the posterior aperture of the carotid canal [13] just in front of the base of that process. The basioccipital (Ba. Oc.) articulates, as viewed thus, with the arcuate hinder margin of basiptery-

goid processes of the basisphenoid in front and with the basitympanic portion of the pterygoid laterally. The parotic process [12] and the overhanging posterior margin of the squamosal (Sq.), stand out behind the suspensory ramus of the quadrate [11].

Posterior view.—The crest of the supraoccipital [14] stands back well beyond the general plane of this aspect of the skull. The exoccipitals (Ex. Oc.) articulating with the supraoccipital above, meet in the mid line below along the length of the condyle, diverging to expose the basioccipital within the foramen magnum. By its parotic ramus [66] each exoccipital articulates with the opisthotic (Op.), and this articulates laterally with the squamosal above, and the otic ramus [16] of the quadrate below. The paroccipital ramus [17] of each exoccipital enters into the formation of the paroccipital process, articulating here with the pterygoid laterally and the basioccipital inferiorly. The condylar rami [18] of the same bones lie above the ramus of the same name of the basioccipital [19]. Looking in and back through the orbit, (Fig. 50) the alisphenoid plate [20] of the parietal may be seen articulating with the epipterygoid process [21] of the pterygoid. Further back the prootic (Pro.) is visible fitted in between supraoccipital above, opisthotic behind, quadrate laterally and prootic process [22] of pterygoid in front. Between the epipterygoid processes of the pterygoids, the rostrum of the basisphenoid is visible [23], and articulating with these same processes above the pedicle of the quadrate [24] is the epipterygoid bone (Ept.).

(B) Regions in detail.

The Nasal Cavity (*cavum nasi*) and posterior nasal passages (*meati choanarum*). The perinasal bones are [1] premaxillae forming the major portion of the floor of the cavity, as well as by their nasal laminae the only part of

the anterior wall; [2], the maxillae forming the lateral portion of the floor and lower part of the side wall; [3], the prefrontals contributing the upper part of the side wall, the whole of the roof, and major portion of the posterior wall, and [4], the vomer forming the remainder of the posterior wall. Two recesses of the cavity are recognisable, a superior and an inferior, the former (*recessus superior*) is that portion of the cavity surrounded on three sides by the prefrontal bone, the latter (*recessus inferior*) is situated well to the front of the cavity in the region of the maxillo-premaxillary suture, just behind the nasal laminae of the premaxillae. The superior recess lodges two nasal sinuses, one of which is the true, physiological, olfactory sac, the inferior recess, one sinus. The nasal fossa extends back above the lower sinus and below the upper two sinuses. The posterior wall of the cavity is very imperfect (Figs. 44 and 46). In the mid line is the V-shaped ethmoidal fissure [58] which intervenes between the nasal plates of the prefrontal bones on either side, the ethnoidal sulcus of the vomer below, and the transverse fronto-prefrontal suture above. This fissure is incompletely closed by the cartilaginous capsule and septum nasi, and through the upper part on either side of the septum the olfactory nerves enter. On either side, below the ethmoid fissure, the posterior wall is rendered imperfect by the large opening to the posterior nasal passage. The boundaries of this aperture are as follows:—above the nasal plate of the prefrontal [59], medially the anterior end of the body and prefrontal processes [60] of the vomer, below the palatino-premaxillary suture, laterally prefrontal process of the maxilla [1] immediately within the posterior nasal passage, in the roof thereof is the lachrymal foramen, this of remarkable size, in the absence of cartilaginous structures, is bounded in front by the nasal lamina of the prefrontal, behind by the orbital plate of the palatine; these two con-

verging to meet medially, the lateral boundary is the lachrymal margin of the maxilla. This foramen transmits a nerve and a blood vessel only, there is no naso-lachrymal duct. The posterior nasal passage is walled in below, laterally and above by the palate bone, medially by the body of the vomer. The two choanæ open close together into a broad semicircular depression, deep in front and shallow behind (*fossa nasopalatina*) [68] which in the entire specimen is divided by a median cartilaginous septum. The nasopalatine fossa is bounded in front and laterally by the arcuate margin of the palate, and may be said to extend back as far as the pterygo-vomerine suture.

The palate (Fig. 47) is bounded laterally and in front by the alveolar margin. Behind, it presents on either side a free border to the zygomatic fossa, and between these its arcuate margin bounds the nasopalatine fossa. The most noteworthy feature is the very expansive vomerine constituent, larger in this and nearly related forms than in any other reptiles. The vomer is flanked on either side behind by the two palate bones; these three bones articulate on either side with the maxillae, parallel to the "oblique palatine suture" thus formed, is a prominent ridge (*agger masticatorius*)[52] beset with conical tubercles. Behind the palatine plates of the maxillae the pterygoid process of the jugals contribute a narrow area [5] to the bony palate.

The Foramen Magnum (Fig. 43) is almost completely enclosed by the exoccipital bones, the supra occipital takes a small share above, but the basioccipital is excluded from the foramen.

The trifaceted occipital condyle stands well out beyond the plane of the foramen magnum. The exoccipital bones take the major share in the formation of the body of the condyle and bear two of the three articular facets. Their

condylar rami [18] hide that of the basioccipital [19] dorsally except within the foramen, and stand out beyond it laterally. Between the three facets is a deep fossa, which for the most part is filled by the articular cartilage, but into the upper part of which the *ligamentum apicis dentis* is inserted.

The paroccipital fossa (*fossa paroccipitalis*) [61] is a concave area on either side of the condyle upon the posterior surfaces of exoccipital and basioccipital bones, at the junction of paroccipital and condylar rami. The fossa is the site of insertion of one of the cephalo-cervical muscles. Above the paroccipital fossa are the external apertures of the hypoglossal canals [53] upon the body of the exoccipital bone.

The paroccipital process (*processus paroccipitalis*) [12] is a prominent outstanding conical tubercle lateral to the paroccipital fossa. Three bones enter into its formation, medially are the paroccipital rami of exoccipital and basioccipital, laterally the process is completed by the paroccipital lamina of the pterygoid. This process is very constantly present in reptilian skulls reaching its minimum of development in some Crocodilia. The basioccipital bone is the most constant component, the exoccipital next in constancy, the pterygoid least constant. I believe that its position and constitution are sufficient justification for the name here applied to it.

The external aperture of the carotid canal (*canalis caroticus*) [13] is on the posterior extremity of the pterygoid immediately to the outside of the paroccipital process.

Immediately above the paroccipital process is the posterior aperture of the spacious acustico-jugular cavity [65].

The parotic process (*processus paroticus*) forms the roof of this cavity. The prootic bone is incorporated in the

parotic process. The exoccipital component is the parotic ramus of that bone [66] which arches over the inner part of the aperture of the cavity, lateral to this the posterior end of the opisthoic appears, bearing at its lower angle the capiti-plastralis tubercle [25]. As seen from above the opisthoic lies obliquely in front of the exoccipital, articulating medially with the epiotic region of the supraoccipital, and with the parotic ramus of the quadrate and the prootic in front. This last bone articulates also with the conjoined rami of the quadrate. Near its hinder end the quadrato-prootic suture is perforated by the temporal foramen [42]. The prootic articulates medially with the epiotic region of the supraoccipital. In front it articulates with the prootic process of the pterygoid, between this articulation and that with the quadrate is the foramen (*foramen zygomaticum*) through which the jugular vein within the anterior portion of the acustico jugular cavity, receives a tributary from the zygomatic fossa.

The anterior margin of the prootic forms the posterior border of the *foramen ovale* [40] transmitting superior and inferior maxillary branches of the fifth nerve. The anterior border of the foramen ovale is the posterior margin of the alisphenoid plate of the parietal [20] and of the epipterygoid process [21] of the pterygoid, anterior and posterior borders converging, meet above; the inferior border is the lamina between epipterygoid and prootic processes of the pterygoid.

The jugular canal [32] issues from beneath the prootic immediately behind the foramen ovale, its outer wall being formed by the prootic process of the pterygoid.

The anterior aperture of the carotid canal is just below and medial to that of the jugular canal, in front of both is a sulcus between the rostrum of the barisphenoid and the pterygoid bone (*sulcus carotico-jugularis*) [51] the lower portion of which as far forward as the carotid foramen [47]

is occupied by the carotid artery, the upper and anterior portion being occupied by the jugular vein.

Let us turn again to the posterior aspect of the skull. Immediately lateral to the posterior aperture of the carotid canal the pterygoid articulates with the suspensory ramus of the quadrate [11] and with that ramus shares in forming the inferior boundary of the aperture of the acustico-jugular cavity, the inner portion of the inferior and the medial boundary are formed by the exoccipital bone. Laterally the cavity is widely open to the post-tympanic notch [73.]

The tympanic cavity is divided into two portions, connected by a canal which occupies the columella sulcus (see Fig. 31) the outer of these (*pars lateralis cavi tympanici*) is lodged in the tympanic fossa of the quadrate, deepened above and behind by the squamosal, and in front and below by the quadrato-jugal. The infra-tympanic spine on the latter bone stands out towards the post-tympanic tubercle on the otic ramus of the quadrate, forming thereby a very incomplete bar across the post-tympanic notch. The inner portion of the tympanic cavity (*pars medialis cavi tympanici*) is situated within the acustico-jugular cavity. According to Hoffman (3) Hasse has designated the whole of this cavity "*recessus cavi tympanici*," even if the cavity were only tympanic it appears that it would be misleading to designate it so, since the tympanic portion is not a recess of that cavity, but lodges the stapedial end of the columella and has both the fenestræ in its inner wall; moreover, this is the only portion of the bony tympanic cavity constantly present in the reptilian skull.

In the occipital region the floor of the cranial cavity is evenly concave, passing insensibly into the lateral wall where this is formed by the exoccipital bone, and here, close to the floor are the internal apertures of the hypoglossal canals (*canales hypoglossi*) (Fig. 48) [53]. Immedi-

ately in front of the exoccipital is an oval foramen between that bone and the opisthotic through which the tenth and eleventh nerves issue (*foramen vago-accessorium*) [39]. Although morphologically this is the equivalent of the jugular foramen of the mammalia; situated as it is between the opisthotic, lower portion of petrosal and the exoccipital; since it does not transmit the jugular vein, it is to that extent anatomically misleading to designate it "jugular foramen," hence the name I have adopted.

In front of the vago-accessory foramen is a big dificiency in the side wall of the cranial cavity (*hiatus acusticus*) due to the incomplete ossification of the periotic bones. So large is the aperture so formed that one can examine the whole of the cavities of the osseous labyrynth without any dissection (See especially figure 49).

Seen through the acustic hiatus the fenestra rotunda [34] is situated just in front of and below the vago-accessory foramen bounded above and in front by the *incisura rotunda* below and behind by basi- and exoccipital bones. The much larger fenestra ovalis [33] is separated from the fenestra rotunda by the interfenestral process [35] of the opisthotic, is bounded in front by the prootic, and is incomplete below. The glossopharyngeal canal (*canalis glossopharyngeus*) [29] perforates the base of the interfenestral process nearer the rotund than oval fenestra. Hoffmann, quoting Hasse, designates this canal '*aqueductus cochleae*'; it certainly transmits the ninth nerve, and I have been unable to find a reason for the name applied by Hasse. The main cavity exposed by the hiatus is the vestibular cavity the prootic recess above and in front of the fenestra ovalis (*recessus vestibularis prooticus*) lodges the utricular recess, and has opening into it the horizontal and anterior semicircular canals, the opisthotic recess (*recessus vestibularis opisthoticus*) lodges the posterior utricular sinus, and has

the horizontal and posterior semicircular canals communicating with it. The epiotic recess (*recessus vestibularis epioticus*) lodges the superior sinus and has the two vertical canals communicating with it.

The articulation of prootic with opisthotic and of both with the epiotic region of the supraoccipital is synchondrotic the articulating cartilage is always large in quantity so that in the macerated skull there is a three rayed cavity in this situation (*fossa spuria*) [50].

In front of the acustic hiatus, the prootic is dimpled by a small but well marked fossa, whose bottom is perforated by two, sometimes three, apertures. This is the internal auditory meatus (*meatus acusticus internus*), the two apertures are the internal aperture of the facial canal (*canalis facialis*) [36] the lower and more anterior of the two, and the anterior cribrose foramen (*foramen cribrosum anterius*) [55] transmitting the vestibular branch of the acustic nerve. This foramen is occasionally double. The cochlea branch of the nerve is transmitted through a posterior cribrose foramen, which in the macerated skull is represented by the cribrose notch (*incisura cribrosa*) [54]. In the complete skull the acustic hiatus is filled by cartilage, which deepens and widens the internal meatus so that the both cribrose foramina are within it.

The facial canal tunnels through the prootic forwards, laterally and downwards, its external aperture, is just visible in the roof of the jugular canal, when that is looked into from in front.

In front of the transverse occipito-sphenoid synchondrosis the basisphenoid is excavated to receive the anterior portion of medullar oblongata. The anterior limit of this "*fossa medullaris*" is an imaginary line joining the bases of the postclinoid processes [45]. In front of this line the cranial floor is lifted clear of the bony basis cranii by a

tough membrane stretched between the processes. The infundibulum rests upon the upper surface of the rostrum of the basisphenoid, the rest of the sella turcica is formed in soft structures, and in front of this the brain box is cartilaginous except for its roof, and the alisphenoid plates of the parietal bones.

The acustico-jugular cavity (*cavum acustico jugulare*) [see especially figure 50] is divided by two tough membranes into three portions, a vago-accessory canal behind, a jugular sinus in front, and the medial portion of the tympanic cavity between the two. The two membranes may be referred to as the anterior and posterior septa. The posterior septum (*septum posterius*) is attached below to the exoccipital; its attachment being commonly marked by a ridge; above, to the same bone parallel to and just behind the opisthotico-exoccipital suture, its medial attachment to the opisthotic in front of the vago-accessory foramen is rarely indicated by a ridge. The anterior septum (septum anterius) is attached below to a ridge on the pterygoid, which, commencing at the hinder and outer corner of the prootic surface passes back and laterally and is continued across the inner aspect of the quadrate in front of the inner end of the columellar sulcus. From the top of the inner end of that groove the septum springs across to the opisthotic, leaving a gap between itself and the quadrate through which the jugular vein passes. The line of its attachment to the opisthotic is usually indicated by a groove on that bone just behind the inner portion of the quadrato-opisthotic suture. The medial attachment, to the prootic in front of the fenestra ovalis is also indicated by a ridge in most specimens.

The inner wall of the medial portion of the tympanic cavity may be exposed by removal of quadrate (see Fig. 50). In such a preparation besides exposing that wall the jugular

sinus would be brought well into view. This sinus has opening into it the temporal canal from above [30], the zygomatic foramen in front laterally [67] and the jugular canal [32], medial to this and further forward.

In its passage across the tympanic portion of the cavity, above the columella auris, the jugular vein is invested by reflexions continuous with the two septa.

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EXPLANATION OF FIGURES.

Fig.

1. Left praemaxilla, lateral aspect.
2. Left praemaxilla, inferior aspect.
3. Left praemaxilla, medial aspect.

1. lamina nasalis	5. facies sagittalis
2. lamina alveolaris	6. facies nasalis
3. lamina palatina	7. facies palatina
4. facies maxillaris	8. facies vomeris

4. Left maxilla, medial aspect.
5. Left maxilla, superior aspect.

1. lamina alveolaris	9. facies nasalis
2. processus praefrontalis	10. facies praefrontalis
3. processus palatinus	11. facies palatinus
4. margo praemaxillaris	12. agger masticatorius
5. facies jugalis	13. facies orbitalis
6. margo orbitalis (laminae alveolaris)	14. facies nasalis
	15. margo lacrymalis
7. margo nasalis	16. facies praemaxillaris
8. margo orbitalis (processi prefrontalis)	17. margo vomeralis
	18. margo palatinus

Fig.

6. Left palate bone, palatine aspect.
7. Left palate bone, medial aspect.
8. Left palate bone, orbital aspect.

1. lamina palatina	8. facies nasalis laminae palatinae
2. lamina orbitalis	9. facies orbitalis laminae palatinae
3. facies palatina	10. margo sagittalis
4. margo vomeralis	11. sulcus nasalis
5. margo maxillaris	12. margo pterygoideus
6. margo jugalis	13. margo lacrymalis
7. margo arcuata	

9. The vomer, lateral aspect.
10. The vomer. palatine aspect
11. The vomer, dorsal aspect.
12. The vomer, posterior aspect.

1. corpus	8. margo maxillaris
2. processus palatinus	9. margo fossae
3. processus praefrontalis	10. facies tecta
4. processus pterygoideus	11. facies naso-palatina
5. sulcus ethmoidalis	12. margo pterygoidea
6. facies orbitalis	13. facies palatina
7. margo praemaxillaris	14. margo palatina

13. Left prefrontal, medial aspect.

1. corpus	6. margo frontalis
2. lamina nasalis	7. margo maxillaris laminae nasalis
3. recessus superior cavi nasi	8. margo ethmoidalis
4. margo nasalis	9. incisura vomeralis
5. margo sagittalis	

14 Left frontal, inferior aspect.

1. crista orbito-sphenoidea	5. margo parietalis
2. semisulcus olfactorius	6. margo postfrontalis
3. facies orbitalis	7. margo prefrontalis
4. margo sagittalis	8. margo orbitalis

15. Left parietal, medial aspect.
16. Left parietal, ventral aspect.

1. corpus	9. margo squamosalis
2. lamina alisphenoidea	10. margo postfrontalis
3. crista orbito-sphenoidea	11. margo frontalis
4. facies cerebralis	12. facies prootica
5. facies lacrymalis	13. incisura pterygoidea
6. facies temporalis	14. margo foraminis ovalis
7. margo sagittalis	15. margo temporalis
8. facies supraoccipitalis	

Fig.

17. Left postfrontal, medial aspect.
    1. margo frontalis
    2. margo parietalis
    3. margo squamosalis
    4. margo quadratojugalis
    5. margo jugalis
    6. margo orbitalis
    7. facies lacrymalis
    8. facies temporalis

18. Left jugal, medial aspect.

19. Left jugal, superior aspect.
    1. margo postfrontalis
    2. margo quadrato-jugalis
    3. margo maxillaris
    4. margo orbitalis
    5. margo zygomatica
    6. processus pterygoidus
    7. margo maxillaris processi pterygoidei
    8. margo palatina processi pterygoidei
    9. margo pterygoidea processi pterygoidei

20. Left quadrato-jugal, lateral aspect.
    1. margo jugalis
    2. margo postfrontalis
    3. margo squamosalis
    4. margo tympanica
    5. margo suspensoria
    6. spina infratympanica
    7. margo zygomatica

21. Left squamosal, medial aspect.
    1. margo squamoso-maxillaris
    2. sulcus squamoso-maxillaris lateralis
    3. sulcus squamoso-maxillaris medialis
    4. margo temporalis
    5 margo parietalis
    6. margo postfrontalis
    7. margo quadrato-jugalis
    8. margo tympanicus
    9. facies quadrata
    10. facies opisthotica

22. Basioccipital, superior aspect.
    1. facies crebralis
    2. facies otica
    3. tuberculum ovoideum
    4. ramus-paroccipitalis
    5. ramus condylus
    6. facies exoccipitalis
    7. facies articularis
    8. facies arcuata
    9. margo basisphenoidea

23. Left exoccipital, posterior aspect.

24. Left exoccipital, inferior aspect.

25. Left exoccipital, superior aspect
    1. corpus
    2. ramus condylus
    3. ramus paroccipitalis
    4. ramus paroticus
    5. ramus supraoccipitalis
    6. facies acustico-jugularis
    7. facies exterior
    8. canales hypoglossi
    9. facies basioccipitalis
    10. facies pterygoidea
    11. facies opisthotica
    12. facies supraoccipitalis
    13. facies arcuata
    14. facies articularis

26. Supraoccipital, inferior aspect.

Fig.

27. Supraoccipital, lateral aspect.
    1. crista occipitalis
    2. facies parietalis
    3. pars epiotica
    4. facies prootica
    5. facies opisthotica
    6. lamina epiotica
    7. sulcus vestibularis epioticus
    8. facies exoccipitalis.

28. Left opisthotic, posterior aspect.

29. Left opisthotic, medial aspect,
    1. facies exoccipitalis
    2. facies acustico-jugularis
    3. tuberculum capti-plastralis
    4. facis supraoccipitalis
    5. facies prootica
    6. recessus vestibularis opisthoticus
    7. canalis semicirularis posterior
    8. canalis semicircularis inferior
    9. canalis glossopharyngeus
    10. processus interfenestralis
    11. incisura rotunda

30. Left prootic, posterior aspect.
    1. recessus vestibularis prooticus
    2. canalis semicircular anterior
    3. sinus canalis inferior
    4, foramen cribrosum anterius
    5. canalis facialis
    6. facies basisphenoidea
    7. facies supraoccipitalis
    8. facies opisthotica
    9. incisura cribrosa

31. Left quadrate, medial aspect.

32. Left quadrate, lateral aspect.

33. Left quadrate, posterior aspect.

34. Left quadrate, anterior aspect.

35. Left quadrate, inferior aspect.
    A ramus oticus
    B ramus suspensorius
    1. facies opisthotica
    2. facies pterygoidea
    3. sulcus temporo-jugularis
    4. incisura temporalis
    5. facies prootica
    6. pediculus
    7. facies pterygo-mandibularis
    8. facies temporo-zygomatica
    9. facies quadrata
    10. tegmen incisurae
    11. facies trochlearis
    12. solum incisurae
    13. sulcus columellae-auris
    14. fossa tympanica
    15. tuberculum post-tympanicum
    16. condylus
    17. margo quadrato-jugalis

36. Left pterygoid, lateral aspect.

37. Left pterygoid, superior aspect.
    A pars pharyngeus
    B pars basitympanicus
    1. margo vomeralis
    2. margo palatina
    3. margo jugalis
    4. facies basisphenoidea inferior
    5. margo sagittalis
    6. processus epipterygoideus
    7. facies jugularis
    8. facies orbitalis
    9. sulcus jugularis
    10. facies prootica

11. facies basisphenoidea superior
12. sulcus caroticus
13. facies basisphenoidea medialis
14. facies acustico-jugularis
15. facies quadrata
16. hiatus posterior canalis carotici
17. lamina paroccipitalis
18. facies exoccipitalis
19. facies basioccipitalis
20. crista pedicularis
21. sulcus pterygo mandibularis
22. os epipterygoideum
23. hiatus anterior canalis carotici
24. processus prooticus
25. facies alisphenoidea

Fig.

38. Basisphenoid, superior aspect.
39 Basisphenoid, lateral aspect.

A corpus
B rostrum
C processus basipterygoideus
1. processus clinoideus
2. pars sellae
3. canalis abducens
4. facies prootica
5. facies basioccipitalis
6. tnberculum ovoideum
7. facies otica
8. facies basioccipitalis
9. facies arcuata
10. foramen caroticum
11. facies pterygoidea

40. The skull. lateral aspect.
41. The skull, dorsal aspect.
42. The skull, ventral aspect.
43. The skull, posterior aspect.
44. The posterior wall of the nasal chamber seen through the anterior nasal aperture.
45. Anterior boundaries of the orbit, lateral aspect.
46. Anterior boundaries of the orbit, posterior aspect.
47. The bones of the palate.
48. The cranial floor.
49. Side wall of the cranial cavity.
50. The acustico jugular cavity, seen from the side after removal of quadrate and squamosal bones.

EXPLANATION OF FIGURES 40—50.

1. processus praefrontalis ossis maxillaris
2. lamina palatina ossis praemaxillaris
3. lamina palatina ossis maxillaris
4. lamina palatina vomeris
5. processus pterygoideus ossis jugalis
6. processus pterygoideus vomeris
7. pars pharyngeus ossis pterygoidei
8. lamina orbitalis ossis palatini
9. pars basitympanicus ossis pterygoidei
10. processus basipterygoideus ossis basisphenoidei
11. ramus suspensorius ossis quadrati
12. processus paroccipitalis
13. hiatus posterior canalis carotici
14. crista supraoccipitalis
15. crista supraoccipitalis
16. ramus oticus ossis quadrati
17. ramus paroccipitalis ossis exoccipitalis

18. ramus condylus ossis exoccipitalis
19. ramus condylus ossis basioccipitalis
20. lamina alisphenoidea ossis parietalis
21. processus epipterygoideus ossis pterygoidei
22. processus prooticus ossis pterygoidei
23. rostrum ossis basisphenoidei
24. pediculus ossis quadrati
25. tuberculum capiti-plastralis
26. ramus paroccipitalis ossis basioccipitalis
27. sulcus pterygo-mandibularis
28. ramus supraoccipitalis ossis exoccipitalis
29. canalis glossopharyngeus
30. sulcus temporalis
31. facies quadrata ossis prootici
32. canalis jugularis
33. fenestra ovale
34. fenestra rotunda
35. processus interfenestralis
36. canalis facialis
37. facies quadrata ossis opisthotici
38. ramus supraoccipitalis ossis exoccipitalis
39. foramen vago-accessorium
40. foramen ovale
41. pars sellae ossis basisphenoidei
42. foramen temporale
43. canalis semicircularis posterior
44. canalis semicircularis anterior
45. processus postclinoideus
46. canalis abducens
47. foramen caroticum
48. tuberculum ovoideum
49. fossa acustica
50. fossa spuria
21. sulcus carotico-jugularis
52. agger masticatorius
53. canales hypoglossi
54. incisura cribrosa
55. foramen cribrosum anterius
56. canalis semicircularis inferior
57. lamina epiotica ossis supraoccipitalis
58. fissura ethmoidalis
59. lamina nasalis ossis praefrontalis
60. processus praefrontalis vomeris
61. fossa paroccipitalis
62. sutura palatino-maxillaris
63. choanae
64. foramen lacrymale
65. cavum acustico-jugulare
66. ramus paroticus ossis exoccipitalis
67. foramen zygomaticum
68. fossa nasopalatina
69. sinus zogomaticus
70. processus paroticus ossis squamosalis
71. sulcus squamoso-maxillaris lateralis
72 sulcus squamoso-maxillaris medialis
73. incisura posttympanica

P.Mx. Os premaxillae
Mx. Os maxillare
P.Fr. Os prefrontale
Fr. Os frontale
Vo. Vomer
Pal. Os palatinum
Ju Os jugale
Pt. Os pterygoideum
Po.Fr. Os postfrontale
Q.J. Os quadrato jugale
Qu. Os quadratum
B.Sph. Os basisphenoideum
Par. Os parietale
S.Oc. Os occipitale superius
Ex.Oc. Os occipitale laterale
Ba.Oc. Os occipitale inferius
Op. Os ooisthoticum
Pro. Os prooticum
Sq. Os squamosale
E.Pt. Os epipterygoideum

SOME ROCK ENGRAVINGS OF THE ABORIGINES OF NEW SOUTH WALES.

By R. H. MATHEWS, L.S.

[*Read before the Royal Society of N. S. Wales, October 5, 1910.*]

DURING my rambles among the large sandstone rocks along the valley of the Hawkesbury river some time back, I discovered some interesting aboriginal drawings, which no one else has brought under notice. It seems to me that the present is an opportune time to try and revive an interest in native drawings, so that when the representatives of the British Association for the Advancement of Science visit this country they may consider it worth their while to bestow some attention upon aboriginal art, and the customs of the natives generally.

I have prepared a diagram, upon which all the figures are accurately drawn to scale, from careful measurements made by myself, and their position on the Government maps is stated in the descriptive letter press, so that they can be readily found at any future time. From the date of the first settlement of Australia by Governor Phillip in 1788 to the present, aboriginal drawings on rocks have been reported by explorers and others in various parts of the continent. But from whatever part of Australia they have yet been reported, they have all been executed in the same manner. A row of holes was first made with a sharp pointed piece of hard stone along the outline of the intended drawing, after which the spaces between the punctures were cut away to a uniform depth, forming a continuous groove around the figure. This resemblance in the workmanship might go to show that the aborigines were either

all descended from the same stock or that they evolved similar customs from corresponding environment.

There are a number of aboriginal drawings cut upon some sandstone rocks at Point Piper, a low headland on the western side of Rose Bay, parish of Alexandria, County of Cumberland. These engravings were described, with illustrations, by G. F. Angus in 1847.[1] Some of Mr. Angus's drawings contain important errors, but they are nevertheless highly interesting, because they show that although these engravings have been exposed to the weather and other wasting influences for 53 years, since the time of his visit, they are still in an excellent state of preservation, with the exception of some which have been destroyed to make room for buildings now erected on the site. In the daily newspapers of more than a year ago, it was stated that Mr. L. Hargrave was of opinion that the above figures at Point Piper were drawn by the Spaniards and that Mr. J. H. Watson believed them to have been executed by convicts since the British occupation of New South Wales. I beg to dissent from both these views, and feel confident that they were the work of the aborigines.

My reason for arriving at this conclusion is because of the vast number of similar drawings which have been reported over an extensive region of New South Wales. The portion of the State in which they are most numerous comprises the counties of Northumberland, Hunter, Cook, Cumberland, Westmoreland, Camden and Vincent. Mr. W. D. Campbell was employed by the Government of New South Wales to copy for publication a great many of these specimens of aboriginal art.[2] I have myself copied and illustrated upwards of two hundred and fifty native draw-

[1] Savage Life in Australia and New Zealand, (London 1847) vol. II, p. 275, plates 1 and 2.

[2] Aboriginal Carvings of Port Jackson and Broken Bay, pp. 1 – 73, 29 plates.

ings in different parts of the area above indicated,[1] as well as in Queensland[2] and Western Australia.[3] By far the greater number of the drawings are situated in localities where convicts or sailors would not be likely to go. In no case have I found any evidence which would lead to the supposition that metal tools had been used in the production of the figures.

The following is a brief description of the figures given on the accompanying block.

Fig. 1. This remarkable drawing is cut on an extensive outcrop of Hawkesbury Sandstone, elevated only a few feet above the surrounding land, near the southern boundary of Portion 99 of 100 acres, Parish of Maroota, County of Cumberland. It is not far from the well known rock called the "Lover's Leap," a precipitous cliff on the right bank of the Hawkesbury River. The entire length of the monster, from the nose along the middle of the body to the tip of the tail-like appendage, measures 37 feet. The eyes are close together, and there is a band around the neck. Two similar bands or belts are cut across the body, with a similar ornamentation on the tail. The widest part of the body measures 6 feet 3 inches.

Fig. 2. A male kangaroo, measuring 7 feet 10½ inches in a straight line from the nose to tip of the tail. From the top of the shoulders along the back to within eight inches of the end of the tail, there is a double line, apparently with the object of increasing the size of the animal, but it also added much to the labour of the native artist. The figure is cut on a flat rock, on a level with the ground, within Portion 40 of 600 acres, Parish of Maroota, County of Cumberland.

1 Journ. Anthrop. Inst., Vol, xxvii, pp. 532 - 541, with plates.

2 Queensland Geographical Journal, Vol. xvi, p. 90; Report Aust. Assoc. Adv. Science, Vol. xii, pp. 493 – 494, plates.

3 Queensland Geographical Journal, Vol. xix, p. 65, plate.

Fig. 3. This peculiar human figure is incised on a flat rock, within the same Portion as Fig. 2, and is only a few chains distant from it. The length is 6 feet 7 inches from the top of the head to the heels. It is apparently intended to show the man's back, the buttocks and the spine being delineated. This position is rare, the front of the individual's body being almost invariably towards the observer.

Fig. 4. Another drawing of a man, 5 feet 4 inches tall, cut upon a sandstone rock within Portion 32 of 60 acres, Parish of Maroota, County of Cumberland. The body is very large in proportion to the limbs.

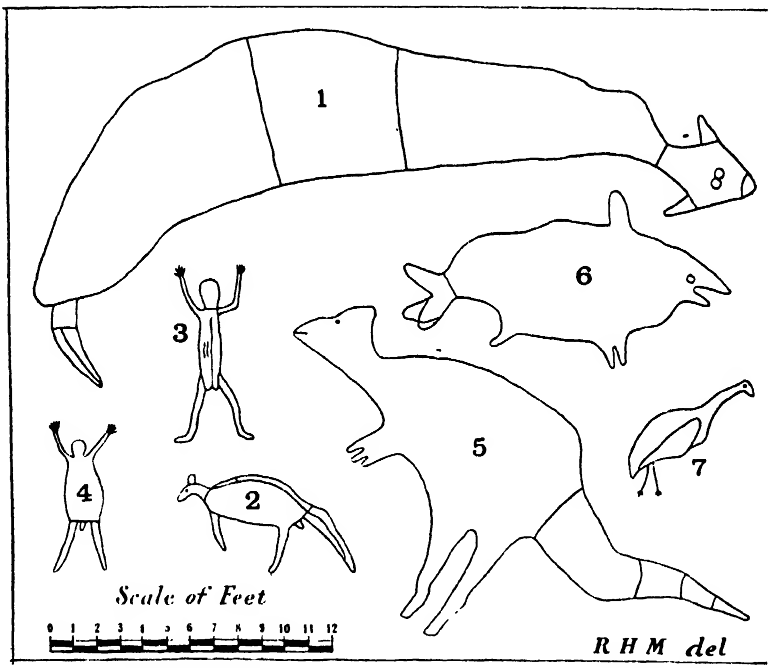

Fig. 5. This enormous kangaroo is cut upon a mass of flat sandstone rock, on a spur sloping back from the northern shore of Middle Harbour, and is close to the northern boundary of Portion 43 of 20 acres, Parish of Manly Cove, County of Cumberland. The animal is 22 feet 3 inches in

length from the point of the nose to the tip of the tail. The eyes and mouth are shown, and there are four bands across the tail. Both the hind legs are represented, but only one of the front limbs. A somewhat defective reproduction of this figure was given by W. D. Campbell in 1899,[1] but its colossal proportions induce me to incorporate it in my plate for purposes of comparison. It appears to be a female.

Fig. 6. A well drawn representation of a fish, 13 feet 6 inches long, is incised on the flat surface of a sandstone rock almost level with the surrounding ground, about 130 yards south-westerly from La Pérouse's monument, Parish of Botany, County of Cumberland. It would appear that the native artist made two attempts to reproduce the lower division of the tail, at the origin of which there is an incised line across the body of the fish. The mouth is open and the eye is depicted by a small incised circle.

On another large flat rock about six chains southerly from the present drawing, is the outline of an immense fish, 38 feet 8 inches long, which I described at the meeting of the Australasian Association for the Advancement of Science held at Brisbane in 1895.[2]

Fig. 7. A bird, perhaps intended for a turkey bustard, measuring 6 feet 2 inches from the top of the head to the end of the tail, is incised on a sandstone rock on the right bank of Byrne's Creek, a tributary of the Wollondilly river, within Portion 5 of 100 acres, Parish of The Peaks, County of Westmoreland. An old blackfellow, about 70 years of age, named "George Riley," a member of the Gundungurra tribe which occupied that part of the country, told me that he first saw this drawing when he was a boy, and even then the grooving had the appearance of having been done a long time.

[1] Aboriginal Carvings of Port Jackson and Broken Bay, pl. 5, fig. 15.
[2] Report, Vol. VI, p. 637, pl. 99, fig. 30. See also Bull. Soc. d'Anthrop. de Paris, Vol. IX, Serie 4, p. 428.

THE HAEMATOZOA OF AUSTRALIAN FISH, No. I.

By T. Harvey Johnston, M.A., B.Sc., and J. Burton Cleland, M.D., Ch.M.

(From the Government Bureau of Microbiology, Sydney, New South Wales.)

[*Read before the Royal Society of N. S. Wales, October 3, 1910.*]

In former papers we have already made known some of the results obtained by us while studying the haematozoa of certain groups of our Australian fauna, namely the Amphibia,[1] Reptilia,[2] and Birds.[3] In this note we have dealt with some trypanosomes found in certain fresh-water fish, and have given a list of our negative and positive findings as regards haematozoa. We have also made mention of a parasitic disease affecting one of our food fishes, though the parasite, a myxosporidian, is not a haematozoon.

Trypanosoma anguillicola n. sp. from the Long-finned Eel, *Anguilla reinhardtii*, Steind, and the Marbled Eel, *A. mauritana*, Bennett. (Figs. 1 – 6.)

To Dr. T. L. Bancroft we are indebted for the first specimens of this trypanosome which occurs in the blood of the above fresh-water eels. Of the infected hosts belonging to the former species, one was captured in January, 1910, and two in May, 1910, very few of the parasites being found in films from the first, though they were fairly numer-

[1] Cleland and Johnston, "The Haematozoa of Australian Batrachians, No. 1, this Journal, XLIV, 1910, p. 252." We omitted to mention in this paper that Dr. T. L. Bancroft exhibited a Trypanosome in the blood of a frog *Hyla nasuta*, before the Royal Society of Queensland in November 1890 (Proc. Roy. Soc. Queensland, VIII, 1890-91, p. xiii). This appears to be the earliest reference to the presence of haematozoa in Australian batrachians.

[2] Johnston and Cleland, "The Haematozoa of Australian Reptilia," No. 1, Proc. Linn. Soc., N.S.W., xxxv, 1910, p. 677 – 685.

[3] Cleland and Johnston, "The Haematozoa of Australian Birds," No. 1, Journ. Proc. Roy. Soc. South Australia, 1910 p. 100 – 114.

ous in the other two. We have found a single example of a trypanosome belonging to the same species in one out of four specimens of A. *reinhardtii*, caught in Prospect Reservoir, near Sydney, in April, 1910. Recently (September, 1910) we have received from Dr. Bancroft, films from another eel, *A. mauritana*, Bennett, from the Burnett River, Queensland, in which the same species of parasite has been met with.

All the specimens examined resembled each other closely. The body was long and narrow, gradually attenuated towards each end. The trophonucleus was seen as a faintly staining structure (using Giemsa) lying in front of the middle of the body, while the deeply staining kinetonucleus was close to the posterior end. The protoplasm stained a deep blue, but appeared to be devoid of granules. The undulating membrane was very distinct but narrow, being about as broad as the body, and was thrown into numerous more or less regular folds. The short flagellum was scarcely recognisable.

The following are the measurements of the parasite:—total length including flagellum about 38μ, (from 35·5μ to 40μ); flagellum 3·7 to 7μ; distance from posterior end to kinetonucleus 1·5μ; from latter to nucleus 16 to 28μ; maximum breadth including undulating membrane, 2·5μ; breadth of undulating membrane, 1·2 to 1·6μ.

This species differs from *T. granulosum*, Lav. & Mesnil., of the European eel *Anguilla vulgaris* in the absence of the large distinctive granules. We propose for it the name *T. anguillicola.*

TRYPANOSOMA BANCROFTI, n.sp., from the blood of the Fresh-water Catfish, *Copidoglanis tandanus*, Mitchell. (Figs. 7–17).

To Dr. T. L. Bancroft of Queensland we are indebted for the privilege of examining and describing this new species

of trypanosome from the freshwater Catfish *Copidoglanis tandanus*, of Queensland rivers. The first specimens Dr. Bancroft obtained are shown in a slide he has forwarded to us, labelled and dated as follows:—" Trypanosome in blood of the Freshwater Catfish, discovered 17/12/'05." This slide shows the very narrow forms with very short flagella to be shortly described, and also several broader forms with basophile granules. In May 1910, we first received from Dr. Bancroft a series of blood-slides from ten of these fish recently taken at Kilroy, Queensland. An examination of these revealed the presence of trypanosomes in only one, but in this one which we have taken as our type slide, the parasites were moderately numerous and of diverse forms. Since then, a further blood slide, dated 27/5/'10, has been received from Dr. Bancroft, in which a single trypanosome was found which, though it differs materially from the specimens we have examined from the other two infected fish, we believe to be a form of the same species—a species apparently characterised by considerable pleomorphism. An examination of the type slide discloses the following variations of the parasite :—

(*a*) Very narrow (under 3 to under 2μ), comparatively short (27 to 31μ) forms. These show a well-marked kineto-nucleus about 1μ from the pointed posterior end; a well-marked trophonucleus 8 to 12·5μ in front of this: and the body passing into the flagellum about 9μ still further forward. The flagellum in some specimens is about 11μ long, in others, apparently only about 4μ in length; while in quite a number of examples very little, if any, of this structure was discernible. We are inclined to think that in these specimens a short flagellum was rendered not visible by injury during, or defects in, preservation. In one specimen some blue granular masses were irregularly distributed in the protoplasm.

(*b*) One very broad specimen was discovered. Its greatest breadth was over 7μ and its length about 50μ. The well-marked kinetonucleus was $1 \cdot 78\mu$ from the beaked posterior end ; the trophonucleus, a faint purple surrounded by a paler area, was about $3 \cdot 5\mu$ in breadth and was nearly $12 \cdot 5\mu$ from the kinetonucleus ; the anterior end narrowed rapidly to end in the flagellum nearly 11μ in front of the trophonucleus ; the flagellum itself was nearly $21 \cdot 5\mu$ long. Three small vacuole-like structures were visible in the anterior portion of the parasite and the whole of the protoplasm was peppered with large deep blue granules, resembling in appearance those of the "mast cells" of human blood.

(*c*) An intermediate form between these two types showing a number of scattered basophile granules, was seen. Its total length was nearly 34μ, and greatest breadth $3 \cdot 5\mu$.

In the blood from a Catfish dated 27/5/'10, the parasite presented a different appearance. Granules were not apparent, but the protoplasm was very deeply stained blue in a somewhat streaky fashion, and the nucleus thereby partly obscured. The kinetonucleus was marked, but a free flagellum as such was not recognisable. A lighter area, now on one side, now on the other of the deeper-stained protoplasm represented the undulating membrane, and this part of the flagellum could just be discerned following the membrane and crossing the body. At its broadest, the membrane was under 2μ in width. This is the only specimen in which we have been able to recognise this structure. This particular parasite was nearly $53 \cdot 5\mu$ long and had a diameter of $4 \cdot 45\mu$.

The species under review seems to approach most closely to *T. granulosum*, Laveran and Mesnil, from the eel (*Anguilla vulgaris*). Like this parasite, our species varies much in size, and certain specimens are characterised by

large and prominent deeply stained granules. The flagellum, however, seems to be distinctly shorter and the undulating membrane less prominent, while in some the anterior extremity narrows rapidly. Laveran and Mesnil in their species do not seem to have met with the very broad form that we have found.

Of the trypanosomes of other freshwater fish, *T. danilewski*, Lav. and Mesnil, of the carp (*Cyprinus carpio*) contains chromatic granules. Its undulating membrane is broad, however, and the flagellum long. *T. remaki*, Lav. and Mesnil. of the pike has no granules.

We propose the name *T. bancrofti* for the species under review, in honour of Dr. T. L. Bancroft.

"MILKY BARRACOOTA," a disease of the Body Tissues due to a Myxosporidian Parasite *Chloromyxum* sp.

The Barracoota (*Thyrsites atun*, Euph.) in Australian waters is subject to a peculiar disease, characterised by a softening and milkiness of the muscular tissue of the body. This fish appears off the West Australian coast in July and August, and, amongst those caught and exposed for sale in the shops, the "milky" ones can be easily distinguished by their more diffluent appearance and softened feel. The disease is also met with in the Eastern States (New South Wales, Victoria, and Tasmania). On incising an infected fish, the muscular tissue is found to be soft and diffluent and almost of the consistency of thick condensed milk. When portions are seized by forceps and held up, thick drops fall from the instrument, still more accentuating this resemblance. The tissue is whitish or slightly blood-tinted and pulls off the bones leaving them bare. An examination of stained films from the softened muscular tissue showed the presence of peculiar bodies arranged somewhat in the form of a Maltese cross. Specimens were forwarded to Prof. E. A. Minchin, F.R.S., in whose hands

they now are awaiting description. In a letter to one of us, he has identified the parasite as a Myxosporidian possessing four polar capsules, and hence belonging to the genus *Chloromyxum*.

The following is a list of species of fish which have been unsuccessfully examined by us for the presence of haematozoa. The date and number of specimens are given. The number of the species in Waite's[1] Synopsis is prefixed to each. Unless otherwise mentioned the fish were taken from Sydney Harbour or the neighbouring waters:—

ELASMOBRANCHII.

6. *Catulus analis*, Ogilby (Spotted Cat Shark), 8/09, (1 spec.)
10. *Orectolobus barbatus*, Gmel. (Wobbegong Shark) Port Stephens. 1907, (1).
11. *Mustelus antarcticus*, Gunth. (Gummy Shark) South Australia, 1910, (1).
14. *Prionace glauca*, Müll. and Henle (Blue Shark) South Australia, 1910, (1).
16. *Carcharias gangeticus*, Müll. and Henle (Sea Shark), Queensland, 1910, (1).
— *Sphyrna tudes*, Cuv. (Hammerhead Shark), Queensland, 1910, (1).
31. *Trygonorrhina fasciata*, Müll. and Henle (Fiddler), Port Stephens, 1907, (1).
38. *Trygonoptera testacea*, Müll. and Henle (Common Sting-ray) Jervis Bay, 7/10, (1).
41. *Dasyatis Khulii*, Müll. and Henle (Blue-spotted Sting-ray), Queensland, 1910, (1).
45. *Myliobatis australis*, Macleay (Eagle Ray), 3/10, (1).
— *Chiloscyllium sp.*, Queensland, 1910, (1).

TELEOSTII.

66. *Cnidoglanis megastomus*, Rich. (Estuary Cat-fish), Hawkesbury, 4/10, (1).

[1] E. R. Waite, "A Synopsis of the Fishes of New South Wales," Memoirs of the N.S.W. Naturalists' Club, No. 2, 1904.

120. *Hippocampus novae-hollandiae*, Steind. (Common Sea-horse), 6/09, (4).

— *Lutianus sebae*, C. and V. (King Schnapper), Queensland, 1910. (1)

— *Lutianus amabilis*, De Vis (Hussar Fish), Queensland, 1910, (1).

212. *Glaucosoma scapulare*, Ramsay (Epaulette), Queensland, 1910, (1).

237. *Scieana antarctica*, Cast. (Jewfish), Queensland, 1910, (1).

— *Scolopsis vosmaeri*, (Big-eyed Bream), Queensland, 1910, (1).

262. *Pagrosomus auratus*, Forster (Schnapper), Port Stephens, 1907, (1).

266. *Lethrinus chrysostomus*, Rich. (Emperor Fish), Queensland, 1910, (1).

269. *Upeneus porosus*, Cuv. and Val. (Common Red Mullet), /09, (2).

270. *Upeneus signatus*, Gunth. (Spotted Red Mullet), 6/09, (1).

305. *Achoerodus gouldii*, Rich. (Blue Groper), Queensland, 1910, (1).

321. *Ophthalmolepis lineolatus*, Cuv. and Val. (Rainbow Fish), Port Stephens, 1907, (1).

325. *Odax balteatus*, Cuv. and Val. (Little Rock Whiting), 6/09, (1).

330. *Seriola lalandi*, Cuv. and Val. (King Fish), Queensland, 1910, (1).

342. *Scomber colias*, Gmel. (Mackerel), 5/09, (1).

348. *Thysites atun*, Euphr. (Barracoota), 7/09, (1).

390. *Echeneis naucrates*, Linn. (Sucking Fish), Queensland, 1910, (1).

395. *Scorpaena cruenta*, Rich. (Spotted Red Rock-cod), Queensland, 1910, (1).

396. *Scorpaena cardinalis*, Rich. (Red Rock-cod), Port Stephens, 1907, (1).

468. *Batrachoides dubius*, Shaw (Frog Fish), 6/09, (2).

— *Balistes capistratus*, Shaw (File Fish), Queensland, 1910, (1).

482. *Monacanthus megalourus*, Rich. (Big-tailed Leather-jacket), 6/09, (4).

— *Monacanthus sp.*[1] (Leather-jacket), Port Stephens, 1907, (2).

495. *Pseudomonacanthus maculosus*, Rich. (Spotted Leather-jacket), 6/09, (6).

502. *Brachaluteres trossulus*, Rich. (Pigmy Leather-jacket), 6/09, (1).

524. *Dicotylichthys punctulatus*, Kaup. (Porcupine Fish) 7/09, (1).

— *Genypterus blacodes*, (Australian Rock-ling), 7/09, (1).

— *Xiphias gladius*, Linn. (Sword-fish), 6/10, (1).

— *Plectopomus maculatus*, (Leopard Fish), Queensland, 1910, (1).

— *Choirodon venustus*, (Blue Parrot-fish), Queensland, 1910, (1).

— *Plectorhynchus punctatus*, (Sweet-lip), Queensland, 1910, (1).

We are not aware of any records of the occurrence of haematozoa in Australian fish, but in the following three species we have seen blood parasites :—

71. *Anguilla reinhardtii*, Steind.[2] (Long-finned Eel), May, 1910, Queensland ; trypanosomes in three examined. Prospect Reservoir, N.S.W., April, 1910; trypanosomes in one out of four examined.

— *Anguilla mauritana*, Bennett (Marbled Eel), September, 1910, Burnett River, Queensland, in one examined.

64. *Copidoglanis tandanus*, Mitchell (Fresh-water Cat-fish), Queensland, May, 1910; trypanosomes in two out of eleven examined.

From the above it will be seen that seventy-seven fish belonging to forty-seven species were examined. Only seven individuals belonging to three species (all from fresh-water) were found to be infected with haematozoa. The percentage of infected species was thus about six, whilst

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[1] In one of these specimens, peculiar "ring-bodies" were detected in the erythrocytes. Johnston and Cleland, Proc. Linn. Soc. N.S. Wales, xxxiv, 1909, p. 508-9.

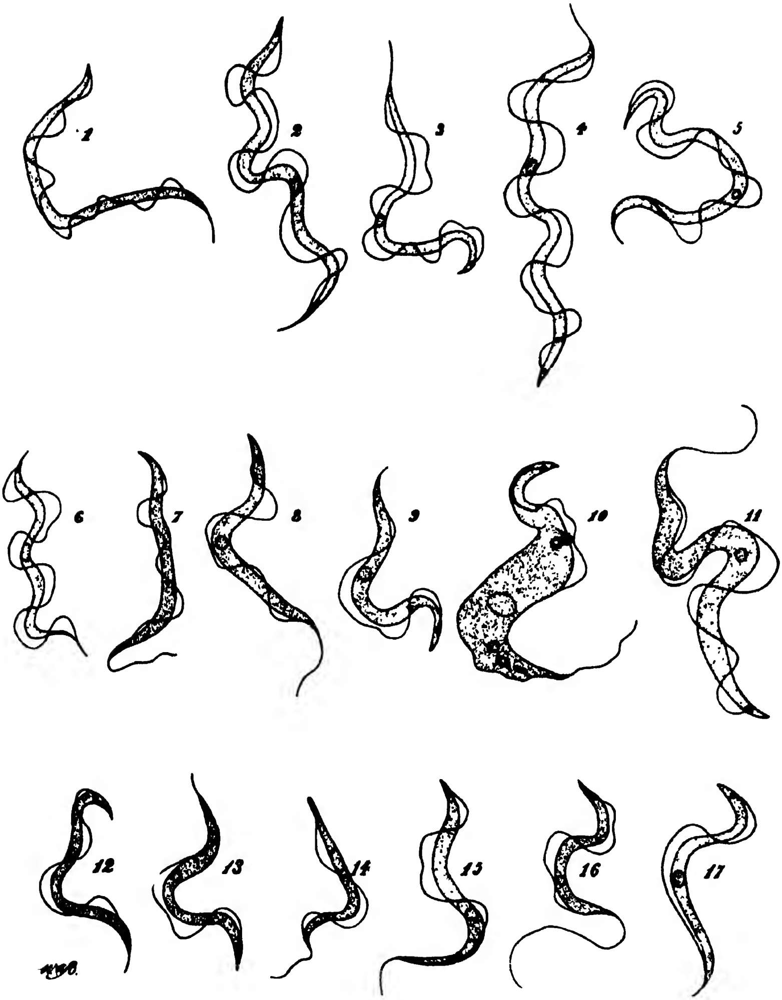
[2] This species is listed in Waite as *A. bengalensis*, Gray.

infected individuals amounted to about 9% of the total number searched. The absence of haematozoa in the marine fish examined is noteworthy. Neuman[1] has recently published an important paper in which he gives an account of the parasites found by him. He examined six hundred and fourteen marine fish belonging to sixty species (p. 4-5), haematozoa being detected in one hundred and twenty individuals in thirteen different species. He also searched films from fourteen specimens of one species of fresh-water fish with negative results. The number of infected individuals (from marine and fresh-water species) was thus one hundred and twenty out of a total of six hundred and twenty-eight examined, the percentage being nearly twenty. He found parasites in fish belonging to thirteen out of sixty-one species under observation, the percentage being nearly twenty-five. His results are thus very different to ours.

The type slides of *Trypanosoma anguillicola* (from *Anguilla reinhardtii)* and *T. bancrofti* (from *Copidoglanis tandanus*) have been deposited in the Australian Museum, Sydney.

Our thanks are especially due to Dr. T. L. Bancroft who found these trypanosomes in Queensland fish and kindly handed over the films to us for description; to Mr. A. R. MacCulloch of the Australian Museum, Sydney, who has been good enough to identify our specimens for us: to the Director, Dr. F. Tidswell; and Dr. E. S. Stokes, for forwarding material, and Mr. F. Hallmann for supplying us, by permission of Mr. H. Dannevig, with a large number of films taken by him from fish captured off Queensland by the Federal Trawler S.S. "Endeavour," and identified by Mr. J. Douglas Ogilby.

[1] Neumann, R. O., "Studien über protozoische Parasiten im Blut von Meeresfischen," Zeitschr. f. Hyg. Infektskr., LXIV, 1909, p. 1 - 112



Figs. 1 – 4 *Trypanosoma anguillicola* from *Anguilla reinhardtii*, (Queensland.)

Fig. 5 *Trypanosoma anguillicola* from *Anguilla mauritana* (Queensld.)

Fig. 6 *Trypanosoma anguillicola* from *Anguilla reiuhardtii* (Prospect, N.S.W.). This figure has been drawn on a smaller scale than the others.

Figs. 7 – 17 *Trypanosoma bancrofti* from *Copidoglanis tandanus*. The specimen figured in fig. 10 was probably damaged.

NOTES ON THE SUITABILITY OF TROPICAL AUSTRALIA FOR THE WHITE RACES.

By Dr. T. V. DANES.

(Communicated by Professor DAVID, B.A., F.R.S., C.M.G.)

[*Read before the Royal Society of N. S. Wales, October 5, 1910.*]

THE paper by Mr. Duckworth dealing with the influence of the climate in Australia, and especially in the Australian tropics upon the white population has been of great interest to me, but I did not join in the discussion, not being prepared for it in a satisfactory manner.

I paid attention some years since to the influence of the tropical climate on the white population, and it seems to me that many points of comparatively great importance have been more or less overlooked, and that in the case of the Australian tropics they especialy deserve attention and proper consideration.

It is a well proved fact that the mortality of the white population in the tropics has diminished, and the conditions of health have been greatly improved in those places and whole countries where modern sanitary measures have been introduced. The adaptation of private life to the exigencies of the tropical climate has been generally of great benefit too. Great consumption of heavy intoxicating liquors, drunkenness combined with carelessness of the elementary laws of tropical hygiene has been certainly one of the greatest evils, and improvement in that direction has brought very good results, especially the condition of the white population in the Dutch East Indies. That the indulgence in liquors, and especially in those of very bad quality throughout tropical Australia as one of the most important causes of ill health seems to be satisfactorily

proved. I beg to call your attention to the statement of one of the best informed authorities, Dr. A. Breinl (Director of the Federal Tropical Diseases Institute at Townsville), who states that alcoholism and other debilitating habits did much more harm to the sugarcane cutters in Queensland than the hard work itself.

We have in general not enough of reliable statistical data illustrating the vital conditions of the tropical indigenous races and of the immigrants from China and Japan. It is something egotistical in the fact, that a close attention is paid only to the white element in the tropics, and that we have not enough material for a reliable comparison as to the conditions prevailing among the other races within the tropics. But there is a great probability, that the mortality and ill-health among the indigenous tropical population, and among the Chinamen is even greater than among the white population, since the sanitary conditions in which they live are generally bad, and especially the exposure to epidemics is no doubt much greater.

As far as Australia is concerned I would like to ask your attention to the following points:—Tropical Australia up to the present, generally speaking, is much healthier than any other tropical country. The aboriginals were a remarkably healthy race, and the European element does not introduce the true tropical evils. But there is a numerous element of alien Asiatics, who continue to live in their most insanitary way also in this country, and that element is to be considered as responsible if some tropical epidemics should be introduced into this continent. It is no doubt a fact that the Chinamen have brought the dreadful "Beri-Beri" disease into the Northern Territory, which spreads also among the white population, as some deplorable cases show. Mostly through the intercourse with Chinamen, syphilis and venereal diseases became widely spread

among the aboriginal population in the Australian tropics, and these diseases, in many cases, became transplanted to the white males, who live mostly unmarried in that part of the country. If the Asiatic aliens are permitted, as up to the present, to live in their own highly unsanitary ways, and to have free intercourse with the other elements, it is certain that in the near future tropical Australia will become much more dangerous to white settlement than is the case now.

Many more or less well informed authors speak and write about the deterioration of the white population in the tropical and subtropical parts of Australia by the influence of the climate. But there are many other influences besides the climate which are to be held responsible, if any deterioration should be proved in reality.

The houses and also the hotels are generally badly fitted for the climatic conditions, especially the corrugated iron humpies, which are the most inappropriate and the most numerous of all kinds of architecture. The general diet can hardly be called good for the exigiencies of the climate. Meat of one and the same kind is the chief nourishment, but is consumed in a state which baffles description, vegetables and fruit are *rarae aves* on the table, especially outside the larger towns. This kind of diet is certainly very unhealthy, especially for women and children.

The water used for all domestic purposes, and even for drinking is very often bad, sometimes even a filthy mud from waterholes, on whose borders carcasses of animals are scattered, and it is really a wonder that epidemics of great virulence do not decimate the population living under such conditions.

I should think that taking these accessory facts into proper consideration, our evaluation of the climate itself would be much more favourable. If the germs giving origin

to the most dreaded tropical diseases should spread through the Australian tropics, the ravages among the population living under the described conditions would be simply stupendous. In my opinion two measures should be taken for the amelioration of the present conditions, and as preventives against the imminent future dangers:—

1. A proper medical sanitary supervision of the alien elements, and the greatest possible restriction of their evil contact, not only with the aboriginals, but also with the white population itself.

2. Improvement of the living conditions of the white population within the tropical and subtropical part of Australia, with special regard to the houses, food and water. The Australian patriotic associations would have here a vast and important field of activity in spreading the knowledge of improved conditions among the white element in the affected parts.

GEOGRAPHICAL UNITY OF EASTERN AUSTRALIA IN LATE AND POST TERTIARY TIME, WITH APPLICATIONS TO BIOLOGICAL PROBLEMS.

By E. C. Andrews, B.A., Department of Mines, Sydney.

[*Read before the Royal Society of N. S. Wales, November 2, 1910.*]

Table of Contents.

I. Introduction.

Definition of title.—By the term geographical unity as employed in the present paper, the writer wishes to convey the idea that during the Pliocene, Pleistocene and Historic Periods, the whole eastern side of the continent moved in the main as a unit, thus giving rise to tectonic and erosional forms practically identical, when considered in strips parallel to the coastline from Thursday Island to the Murray River in Western Victoria. The inference from this is not that each strip has arisen or subsided exactly in the same degree, but rather that the movement of the eastern continent, as a whole, has been similar during each successive period. For example, it is not here considered that the Miocene shoreline corresponded with the present one. On the other hand the idea is here advanced that Eastern Australia was a peneplain raised but little above sea level toward the close of the Miocene, and that its shore line doubtless lay considerably to the eastward. The present shore line is here considered as belonging to the Human Period, while the plateaus and the main outlines of the continental shelf are considered as being due to agencies which closed the Tertiary Period. Again, the peneplain of Eastern Australia was so warped and faulted at the close of the Pliocene, or the commencement of the Pleistocene, as to be carried upwards to heights varying from 1,500 to 7,300 feet above sea level, with the production of great block faulting in its south-eastern knot; nevertheless upon a broad view the Highlands appear to be a flat arch, somewhat like a boomerang in plan (Fig. 1), the long curve of which parallels the coastline. Considered as a whole the plateau surfaces slope away east and west from a sub-horizontal surface, yet the local plateau surfaces may slope to the north-west, as at the heads of the Barwon, to the north-east[1] as to the

[1] Carne, J. E., see literature.

east of Mount Victoria or even to the south and south-east as on the coastal fall of Victoria. Similarly, during the recent subsidence of Eastern Australia the southern and northern portions of the continent were perhaps drowned in a greater degree than the Sydney area, nevertheless a magnificent and similar system of harbours has been formed along the eastern continent by that movement. Other points, such as the variable movements in Miocene and Pliocene time will be discussed in the body of the report.

Scope of report.—The intention, in this report, is to supply a fairly detailed account of the history of Eastern Australia during and after, the "Newer Volcanic Period" of the Victorian geologists. Such period is here considered as belonging to the Pliocene, both on physiographic and palæontological grounds, although the fossil evidence of such age is considered as unsatisfactory by such eminent authorities as Hall, Chapman, Pritchard, Maiden and Deane. The Eocene and Miocene history is dealt with but briefly, its fuller treatment being reserved for Part II of this series. The significance of the altitude of the "Deep Leads" of the "Newer Volcanic" Period is considered, as is also that of the denudation of the "Newer Volcanics" themselves; of the fossil contents of the "Leads" underlying the "Newer Volcanics"; of the variation in plateau, coastal, and shore topography; and of the unlike floras of the present time and that of the "Leads."

Position of Geography and Physical Geology in Science. Geology and Geography are not branches of pure science like chemistry, physics or biology, but are what may be called eclectic branches of science. An intimate knowledge of at least one branch of pure science is necessary for their understanding, coupled with keen powers of observation, so as to put a check upon the unscientific use of the imagination. He who would understand the principles

of physical geology and geography must continually hold converse with the face of the earth itself. He must know it well in plan and in section. Like Antæus of old, he must look for accessions of strength from continual contact with earth. He must easily grasp the significance of the commonplaces of observation, no fact must be too trivial for consideration, and he must be able readily to appreciate the legitimate use of analogical method. Hitherto the treatment of problems of physical geology has been mainly entrusted to mathematical savants who have had no intimate knowledge of geological method, such as is provided by the detailed mapping of a large area, the preparation of detailed geological sections or by accurate observation of the earth in plan during extensive travel. The mathematical computations of the age of the earth are examples of the futility of geological or geographical speculations based without reference to comparative studies.

It must not be forgotten that all real progress in geology has been observational and inferential, nevertheless the understanding of ordinary mechanical principles by geologists would make for much greater progress than at present experienced, just as the application of biology to geology has done so much for geological progress. This is well illustrated by a consideration of the problem under discussion, namely, the attempt to prove the geographical unity of Eastern Australia in late and post Tertiary time.

It will be seen as this report is read that no amount of palæontological knowledge only on the one hand nor the knowledge of mathematical physics alone on the other would have sufficed to interpret the wondrous history of the eastern continent as a whole in late and post Tertiary time. The problem, however, is amenable to treatment by the more elementary principles of mechanics and biology, by close attention to the inductive method, and by a legitimate use of analogy.

Use of analogical method.—An example is here given of the application of the analogical method to problems of late and post Tertiary age in Eastern Australia when the palæontological criteria of age available are not conclusive.

(*a*) From Thursday Island on the north to the south-west of Victoria, a warped and faulted plateau surface may be traced apparently parallel to the shore line. This irregular surface was once continuous. It is now diversified with wide shallow valleys, along which profound cañons are receding, the cañon streams themselves having been rejuvenated on several occasions. On the high-level surface also lie numerous "Deep Leads" or buried river channels. The greatest irregularities, or block faultings, of the plateau occur in the knot of the Australian Alps formed at the angle where the plateau of Eastern Australia swings from an eastern to a northern direction, the whole making a magnificent arc convex to the Pacific. The eastern slope of this plateau descends more rapidly to the Pacific by faultings and warpings than does the western slope to the inland plains, with the exception of the western fall of the Australian Alps, which in turn break away more rapidly inland than to the ocean.

(*b*) The topography of the western side of the United States is similar in a general way to that of Eastern Australia, the elevation, the block faulting, and the dissection of the North American area being on a grander scale, however, than that of Australia. "Valley in valley" appearance is also characteristic of the American valleys.

(*c*) The peneplanation of Western America has been generally assigned to Tertiary activities. The Pliocene has been considered as the period during which the excavation of excessively broad valleys (incipient peneplains) took place, while the plateau-forming period, the block faulting, and the formation of such gorges as those of the

Merced, the Colorado and the Arkansas are generally assigned to the Ozarkian or Sierran Period (Pleistocene of Le Conte and others).

(*d*) The igneous and sedimentary complexes out of which the western North American and eastern Australian surfaces have been excavated, are almost identical in chemical and physical properties.

(*e*) The laws of hydrostatics and hydrodynamics have been identical both in Australia and in America during Tertiary and post Tertiary time.

(*f*) The main agents of erosion have been the same in each area.

(*g*) The amount of rainfall, the variations in heat and cold as well as the other physical phenomena involved in each area have been comparable from a quantitative point of view during Pliocene and post Tertiary time.

(*h*) The flood stream has been, and is, the main agent in the corrasion of rock structures the world over.

Therefore if a peneplain has been formed near sea level over the western side of the North American continent during Tertiary time, it is legitimate to consider that a peneplain could also be carved out of Australia during the same time. A closing Tertiary age may be assigned to the great plateau formation, the fault scarps therein and the profound gorges which have cut their ways into the tableland. Additional evidence of the late or post Tertiary age of the plateaus and gorges is presented in the body of the report.

The writer here desires to acknowledge the great help he has received from a perusal of the works[1] of David, Baron von Mueller, Murray, Wilkinson, McCoy, Carne, Hedley, Skeats, Jensen, Hall, Chapman, Gregory, Süssmilch, Cambage, Maiden, Deane, and others in the preparation of this report.

[1] List of this literature supplied in appendix.

In closing this introductory chapter attention is called to the grand pioneer work of Clarke, David and Wilkinson on the origin of our continental margins. Thus Wilkinson considered the Illawarra escarpment as one fault and the steep face of the continental margin as another. His results appear to have been based mainly upon intuition, whereas David's great contribution was the result of comparative studies. By the sure methods of stratigraphy the latter geologist actually proved beyond doubt the existence of several of the fault and fold lines of the Plateau or Highland[1] Period. What David thus laid down on a sound geological basis the writer has carried on by physiographic method.

To Carne [Kerosene Shale and Western Coal Memoirs] we are indebted also for our knowledge of the irregular slope of small angular value which has carried the sandstone surface from sea level between Sydney and Newcastle to a height of nearly 4,000 feet at Clarence Siding.

To Hedley and Benham the writer is indebted for his knowledge of the geographical distribution of animal life in Australasia, while to Maiden and Cambage he is indebted for his knowledge of the present distribution of plants in Eastern Australia. It is hoped that the present report will be of service to biologists and geologists generally.

The list of literature is supplied at the end of the report. The references at the feet of the pages refer to this list.

II. Thesis.

Eastern Australia has been a geographical unit during late Tertiary and post Tertiary time. A peneplain was developed during Eocene and Miocene time. That pene-

[1] To this momentous period in the late history of Eastern Australia the writer would suggest the name of the Kosciusko Period, after the famous mountain and range of that time, which form the grandest and best known horst of the East Australian Highlands. Throughout this paper the late Tertiary uplift will be called the Kosciusko Period.

plain was developed but little above the level of the surface of the sea. Floras during the Miocene appear to have been uniform and of tropical to subtropical affinities, besides being unlike those to be found in Australia to-day. The Pliocene was partly a period of sedimentation and partly of erosion. The flora of this period was unlike that of the present day.

The close of the Tertiary was marked by the development of a great series of faults, whose main scarps parallel the present continental margin, from Thursday Island in the north to south-western Victoria on the south. The great fault blocks produced by these dislocations are tilted generally to the west, and thus the north and south river courses are forced against the eastern scarps of the associated upfaulted blocks. Minor cross faults relieved the general peripheral strain of the continents. An intensity of movement was experienced at the angle formed in the south-eastern corner of the continent, and here the maximum height of the plateaus is found. Typically the eastern fall of the highlands is the steepest, and such fall occurs in the form of large subparallel warps, block faults and flexures. These are best developed in the south-east of Australia, in eastern New England, and in northern Queensland. The marvellous cañons of the three regions thus enumerated are due to the youthful dissection of these fault blocks.

The continental shelf is a portion of the coast line which was downthrown in closing Tertiary time and which has been altered to a sloping terrace, first by wave erosion and sedimentation, and secondly and much more recently, by submergence combined with erosion and sedimentation. To this double set of activities also belongs the Great Barrier Reef of North Queensland.

Tasmania represents a mass whose northern scarp parallels both the main directions of Bass' Strait and the

Victorian Main Divide, while its eastern and western scarps and warps parallel the associated coasts. Inland it appears also to have collapsed in terraces and senkungsfelder so as to form both the "Midland Valley" and the Lake Region of the Island.

The great uplift which closed the Tertiary isolated the coast from the interior. A complete modification of faunas and floras resulted both by reason of the isolation and by reason of the climatic changes induced by this topographic revolution. The plateau was breached locally by later Pleistocene erosion along a line of weakness, and a moderate intermingling of recently isolated life types resulted.

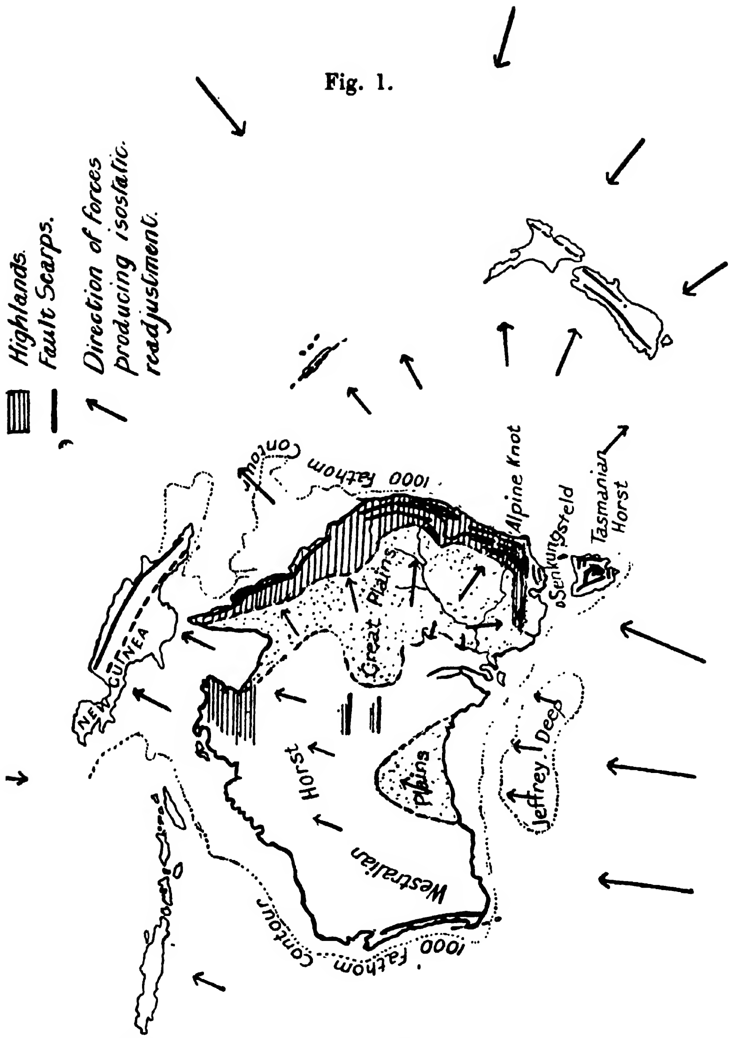
III. General Topography.

Eastern Australia may be divided into (*a*) The interior. (*b*) The Highlands, the faulted and downwarped surfaces and the continental shelf. (See Fig. 1.) These may again be subdivided, and with the exception of the inland area, the various subdivisions of this half of the continent show a decided correspondence with each other. A glance at Figs. 1 and 2, is sufficient to reveal the peculiar relations between the various parts. For example the correspondence between the Great Divide of Victoria, Bass' Strait and the northern Tasmanian mountains is evident, as is also that of the width of the middle Queensland coastal area with the breadth of the associated continental shelf.[1]

(a) *The Interior of Eastern Australia.*—The eastern margin of the interior corresponds approximately with the trend of the coast line. The interior itself consists partly of plateaus and partly of Black Soil Plains. The greater portion of the plateau here in New South Wales and in the southern portion of Queensland is less than 1,000 feet above sea level, and is dissected by broad, shallow valleys whose

[1] This fact concerning the "shelf" has also been mentioned by Mr. C. Hedley in conversation with the writer.

Fig. 1.



The Geographical Subdivision of Australia.—The Westralian horst is low. It presents concave curves to the Antarctic. The Eastralian horst is less stable than the Westralian example. It faces the Pacific in a ccnvex curve, and is separated from the west by a heavy sinking area. The concave coast line from Hobart to the Leuwin appears to indicate a faulting from the Westralian horst, owing to isostatic readjustment in late geological time. Central Australia, the base of the Tasman Sea, the Jeffrey Deep, and the base of the South Pacific may be considered as four "negative" or heavy areas, the readjustments of whose masses has led to the formation of the Australasian and New Zealand plateaus in closing Tertiary time. The arrows indicate the directions from which the forces came which produced the vertical readjustments which resulted in the formation of the fault blocks. This scheme is merely a suggestion for intending workers in this field.

bases are now filled with alluvium. The Darling system flows over this almost featureless surface, and 1,000 miles from the sea is only from 300 to 400 feet above sea level. The plateau is composed of Pre-Palæozoic, Palæozoic, Jurassic, Lower and Upper Cretaceous rocks indifferently.

The area between the Murray and Murrumbidgee Rivers is composed of low lying black soil plains named Riverina. Immense areas of "black soil" plain also extend along the branches of the Darling River system, and partly drown the plateau just described. The rainfall over this area varies from 20 to 30 inches on the eastern margin of the interior to less than 10 inches on the western boundary of New South Wales. Many of the large streams which rise in the Great Divide fail either to reach the Darling or the sea, but die away in marshes, in salt lakes, or "clay pans." A characteristic of the large streams as they traverse the "black soil" is the wealth of ana-branches and of lagoons or billabongs possessed by them. It may here be pointed out that in later Tertiary time the land of the interior was moderately raised and that the streams such as the Darling and Murray occupy broad valleys in its surface. Subsidence and alluviating processes followed, while at present the streams are excavating and destroying the plains in turn, because material is not now being carried down from the highlands in such quantities as in recent geological time.

(b) *The Highlands and the Great Divide.*—The Main Divide of Eastern Australia lies in the Highland region, but the latter is not confined to the Main Divide.[1] As will be shown later, the Highlands of Eastern Australia consist of a peneplain which was raised, warped and faulted at the close of the Tertiary Period and the Main Divide is therefore of extreme youth. Frequently the highest portions of the

[1] See also Gregory, J. W., (a) pp. 93, 94.

plateaus are not in the neighbourhood of the Main Divide, but represent faulted masses east or west of the main water parting of the continent as at Guy Fawkes in New England, the Victorian Alps, and the Bellenden Ker Ranges in North Queensland. One significant fact stands out however, upon even a casual study of Australian geography, and that is that highlands and Main Divide are approximately parallel to both coast line and the edge of the continental shelf. From the coast line the highlands generally extend inland for several hundreds of miles, the upper plateau surface exceeds one hundred miles in width in places, and it is warped and faulted east and west to coast line and inland areas respectively. The general height of this upper level is about 3,000 feet above sea level, but numerous masses have been faulted to much greater heights. These will be discussed later.

Although the general slope of the plateaus is west and east along the eastern border of the continent, and north and south in central and western Victoria, nevertheless, there are great local deviations from this rule, but these do not affect the main problem. In dealing with the highlands there are several important points to be taken into consideration, and these are dealt with briefly at this stage of the discussion.

(1) *The mountain knot at the south-eastern corner of Australia.*—One of the most interesting and instructive topographical features of the highlands is the group of mountains, or plateaus, in south-eastern New South Wales and north-eastern Victoria known as the Australian Alps (Figs. 1 and 2). Whereas the general height of the plateaus in other portions of Australia is about 3,000 feet, and rarely exceeds 5,000 feet, the height of this portion of the highlands varies from 5,000 to 7,300 feet. It is situated in the angle made by the junction of the eastern and southern

plateaus, and appears to be due to the intensity of activity caused by conflicting earth forces in this angle. The Australian Alps themselves are faulted plateaus which lie on the western edge of the south-eastern highlands. This heavy faulting dies away north and south in minor faults and flexures (Fig. 2). A very heavy fault throwing north-west occurs at the Buffalo Mountains.

(2) *Coastal and inland plateau slopes.*—As a rule the coastal slope of the plateau is more abrupt than the inland one, but in the south-eastern portion of Australia the north-western to western slope of the plateau is more abrupt than the coastal fall. This is a most significant fact.

(3) *Convexity of plateau curves to the oceans.*—The highlands of eastern Australia "curve sympathetically" with the coast line, and thus make a magnificent curve convex to the Pacific Ocean. The Victorian highlands are convex to the Southern Ocean (Fig. 1).

(4) *The Australian Alps, Bass' Straits and Tasmania.*—Tasmania is connected with the mainland of Australia by the wide continental shelf. The Victorian Main Divide, Bass' Strait, the northern shore line of Tasmania, and the northern face of the Tasmanian plateau are all parallel to each other and appear to be definitely related to each other. Tasmania appears to be a block against which closing Tertiary forces came into conflict and Bass' Strait appears to be a submerged flex (Figs. 1 and 2).

(5) *Tasmania* appears to consist of a high central mass traversed by block faults. The southern, eastern, and western portions are strongly folded and faulted under the sea. Both the famous "Tiers" and some of the lakes of the central area appear to be due to block faulting by a collapse of the more central masses.

(6) *Faulting and flexing.*—The faults and flexures of the eastern Australian highlands and offshore areas are numer-

ous, but the topography has not been examined systematically, and it will be many years before a complete list of even the more important faults and flexures is obtainable. Only a few are here mentioned. The physiographic criteria by which the faults here considered have been recognised are as follows:

(a) *Dissection of faulted blocks.*—Frequently two plateau blocks are found separated by an escarpment. The surface of the lower block forms a local baselevel for the drainage of the upper block. In such cases deep cañons may be seen receding simultaneously along both blocks, the cañons of the lower plateau not having eaten their way back to the higher [upfaulted] blocks. Examples, the Kosciusko, Guy Fawkes, Darling Downs, and other plateaus.

(b) *Similarity of topography upon two or more plateau blocks* when escarpments separate the various uplifted masses. Before a peneplain is formed in a raised land mass the latter has reached such a stage of dissection that but slight traces of its original surface are visible. Therefore if several land surfaces exist at various levels, all possessing similar topographical features and each separated from the other by an abrupt change of slope, then it is reasonable to conclude that the various surfaces represent the faulting of a once continuous land surface.[1] In a previous paper (Tertiary History of New England) the writer considered certain levels, such as the Bolivia Plain, to be peneplains of two distinct ages. These however, merely represent faulted and flexed blocks of the late Tertiary peneplain in New England. There are, it is true, traces everywhere throughout eastern Australia of two distinct surfaces of erosion, but the number of true peneplain surfaces cannot be indefinitely extended, the highest members almost without exception being fault blocks. It would appear, in fact, that

[1] See also Süssmilch (a) pp. 344, 345.

wherever in eastern Australia two unreduced plateau masses exist side by side at variable altitudes a fault or sharp fold separates them. The grandest examples of faulting appear to have occurred at the edge of the continental shelf. By this action the outer edge of the continent appears to have been carried down to ocean depths.[1] The date of this may be assigned to the close of the Pliocene or the commencement of the Pleistocene.

It will be seen that this warping action has been most pronounced opposite to those points where the highlands have been raised most abruptly. Thus along the southern portion of New South Wales where the mountains are highest and where their distance is least removed from the ocean, there the opposite condition of affairs is found to that off the central portion of the Queensland coast. The next most important flexing and faulting has resulted in the formation of the continental shelf.

The origin, however, of this topographical feature has been dealt with at length by Hedley,[2] and only a brief note is made here of it. A warp and filling appears to have determined this feature. As the result of that movement a portion of the old coast was submerged. "Wave base" was formed and the coast was attacked at the same time that the land was deeply dissected by the rejuvenated land streams. The products of such erosion were carried beyond "wave base" to form a plain of sedimentation the while the sea advanced on the land to form a submarine shelf. Later came the subsidence during the Human Period by which action the Pleistocene shelf was deeply drowned and the recent shore line was depressed for several hundreds of feet. By such action the shelf may be seen to be due to

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[1] For a general discussion of continental borders see the masterly treatment by Chamberlin and Salisbury in their Geology, III, pp. 526, 528.

[2] Hedley, C., (a).

at least two Post-Tertiary activities resulting in, first, a smooth outer edge for the shelf, and second a rough inshore portion dotted with islands. This double nature of the continental shelf has been pointed out by Hedley.[1]

If now attention be directed to the highlands themselves, it will be seen that in those places where they are most lofty and closest to the coast, there the country breaks down in steps, in senkungsfelder, and in flexures, to the sea. These faults and flexures are frequently arranged parallel to the shore line or continental shelf, and in the south-eastern portion of the continent where the mountain knot occurs at the locality where the highlands turn from east to north, the faults and flexures appear as somewhat parallel curves. Thus the Kosciusko or Muniong Range with its continuation into Victoria as the Bowen Range is one great fault block as is also the line of the Victorian Alps, while Omeo and Lake Omeo appear to occupy a senkungsfeld between these horsts (Fig. 2). The great escarpment on the Big Bogong of New South Wales appears to be a fault along the northern continuation of the Muniong Range. The long and steep scarps of the Wanderer and Gourock Ranges also represent faulted blocks, as do also the subparallel Cullarin, Cowley and Muniong Ranges. The Snowy River occupies the southern senkungsfeld thus formed, while the Murrumbidgee occupies one of the northern senkungsfelder.[2] Between the Cullarin and Gourock Ranges lies the senkungsfeld containing Lakes George and Bathurst as described by T. G. Taylor.[3]

Braidwood also appears to occupy a senkungsfeld or tilted block bounded by two ranges parallel to coast. The upper Shoalhaven drains the upper portion of these faulted or

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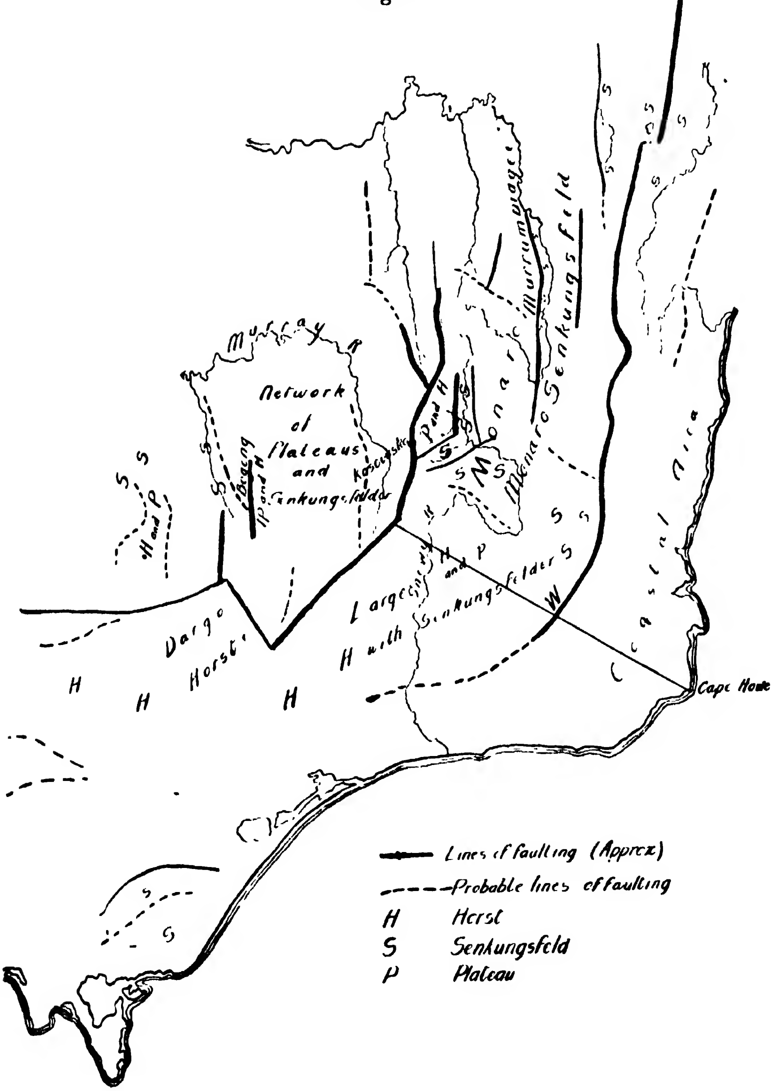
[1] Presidential Address, Proc. Linn. Soc., 1900.
[2] See also Süssmilch with regard to the Murrumbidgee senkungsfeld, (a) pp. 343, 344.
[3] Taylor, T. G., (a) See literature.

warped masses. Similarly for the upper Hawkesbury with the Wollondilly horst to the west. The upland valley of this river above Burragorang is about 2,600 feet above sea level, the western horst being about 3,500 feet in height. The same horst exceeds 4,000 feet a few miles east of Bathurst, and the Bathurst Plains (2,500 feet) appear to be a senkungsfeld dropped between the Orange and Sunny Corner highlands. This interesting topographical feature will be discussed in detail by Mr. C. A. Süssmilch in the near future and is here mentioned only as one of the important block faults of eastern Australia. One portion of the Hawkesbury River known as the Nepean, has had its direction determined by the Kurrajong Fault and Lapstone Hill Fold described by Professor T. W. E. David.[1] These features also parallel the coast and their tectonic origin has been determined by stratigraphic methods.

Further north the Nandewars appear to be either a fault or monoclinal fold carrying the highlands rapidly under the Black Soil Plains. Tingha lies on a block warped down from the Guyra horst, and Inverell lies on a block faulted off the Tingha plateau, Middle Creek ravine shows the youth of the faulting. The high plateaus of Guyra, Ben Lomond and Guy Fawkes are upfaulted blocks, while the Armidale plateau is a relatively depressed area. Guyra and Ben Lomond lagoons appear to arise from warping action. Guy Fawkes breaks away in several great steps (one called the Dorrigo) to the sea. The upper surfaces of these horsts are frequently covered with swamps representing the filling by waste of depressions due to warping. The high country along the south arm of the Clarence in the neighbourhood of Dundahra, Coombajha and Cooraldooral (west and south of Cangai) marks the line of a long and powerful fault.

[1] David, T. W. E., (a)

Fig. 2.



Sketch lines of some important faults in south-eastern Australia. These lines are only approximate.

In north Queensland the whole coast from Hinchinbrook Island to Cooktown has been strongly faulted or flexed beneath the sea, and so recently has this occurred that the powerful streams of the Barron, Johnson, Tully and related rivers have only succeeded in cutting their profound cañons to distances of from 20 to 30 miles from the sea. The Bellender Ker Ranges appear to represent a horst in this region. Such faulting action parallel to the coast is probably not older than closing Tertiary.

In passing on from this brief mention of a few of the more important topographic faults of the eastern Australian highlands, it may be advisable to call the attention of physiographers to the rich harvest of information [with regard to faulting and flexing] which is to be reaped from a careful study of Tasmania, the Victorian Alps, the south-eastern corner of New South Wales, eastern New England, the southern Darling Downs area, and the coastal area lying between Townsville and Cooktown in North Queensland.

(7) *Plateau dissection by streams.*—By this subheading the amount of dissection only is indicated which the plateau has suffered by stream action since the last important uplift. The broad and shallow mature valleys, which mildly roughen the upland surfaces themselves, are not considered in this connection as they belong to the pre-Kosciusko Period.

(a) *Depth of dissection.*—We infer that the uplift of the plateaus has been considerable, because of the great depths of the cañons trenching their surfaces. A few instances, from the many known to the writer, of the depth of the dissection attained may be quoted at this stage.

The plateau surface of the Big Bogong in Victoria is 6,500 feet high, while the channel of the Kiewa as it leaves the mountain is only 1,500 feet above sea level.

The base of the Murray gorge a score of miles below Kosciusko (7,300 ft.) is 6,000 feet below the same plateau surface.

The Hawkesbury is 330 miles in length. Near its source the plateau has been faulted, the Jenolan horst to the west is about 3,500 feet in height and the lower faulted mass is about 2,600 feet in height. Along this lower level the upper Hawkesbury or Wollondilly flowed until such level was dissected by the headward recession of the stream. The Wollondilly now occupies a V shaped gorge in the porphyry plateau, the base of the gorge being only 600 feet above sea level, even as much as 200 miles up stream.

The cañons of the Macleay headwaters are 2,000 feet deep a few miles below the commencement of their torrent and waterfall stages.

The Bellinger western headwaters descend 4,000 feet within a distance of 10 miles, and 5,000 feet within a distance of 30 miles. In the case of the Bellinger, however, this wonderful dissection has been aided by block faulting. The view from the fault block is one of the most impressive on the continent.

The South Clarence is only 280 miles in length, but at a distance of 150 miles from its mouth it is only 300 feet above sea level, while the plateau surface to the immediate west is about 4,000 feet in height.

Equally striking facts of dissection may be cited for the north coast of Queensland and Tasmania.

(b) *Stage of dissection.*—Profound as are the cañon depths which score the plateau surfaces, nevertheless the stage of such dissection is a very youthful one. Although the coastal streams have such short courses yet their cañons have not retreated to the Main Divide, except in one or two places, as at the Liverpool Range in New South

Wales, where the geological structures are relatively weak. In Monaro, New England, in the palæozoic areas west and south of the Blue Mountains, and in other localities vast areas of plateau exist which have not been dissected as yet by the formation of the deep cañons which sprang into being when the plateaus were formed by faulting and flexing activities. The general appearance of the profound cañons of eastern Australia is similar to that of the Merced example in California, while the Grand Cañon of the Colorado is only a larger example of plateau dissection by streams. The plateaus of the Rocky Mountains, the Sierra Nevada and of other localities in North America are not more dissected by cañons than are those of eastern Australia. Nevertheless, literature is full now of descriptions of the closing Pliocene[1] or even Post Pliocene[2] Age of this plateau dissection in North America. From physical principles[3] the age of our eastern Australian plateaus may also, by analogy, be placed at the close of the Pliocene.

As might have been expected, the topography is wildest and most immature in the region of the great fault blocks. It may be interesting to see how youthful is the stage of plateau dissection in eastern Australia by a reference to the early history of the colonies.

For many years the inland area remained unknown to the early English colonists of New South Wales and Queensland. Time after time they attempted to force a way across the Main Divide, only each time to be baffled by the great sandstone, granite or slate ramparts which stretched away "illimitable to the horizon." The English brought with them their own mountaineering methods and sought

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[1] Chamberlin and Salisbury, Geology, Vol. III, pp. 311 – 318.

[2] Journal of Geology, 1910, Vol. XVIII, pp. 227 (by J. Perrin Smith).

[3] In the immediate future a discussion of the peneplain from a simple dynamical point of view will be presented by the writer. Some hitherto unrecorded facts will be presented.

to cross the Main Divide by following the thalwegs of the Australian streams. Only when they turned their attention to the leading spurs, however, were the Blue Mountains scaled. Some years later both New England and the Darling Downs were discovered by adopting the same plan.

IV. Valley and "Lead" Topography.

(A) The evidence of the Valley Systems.—Coming from the east, one notices that the intensely blue water of the deep sea rapidly changes to duller hues when within a few miles of land. The continental shelf thus entered upon is narrow, the shore portion being roughened by islands.[1] The shoreline topography shows harbours, lagoons, coastal plains, raised beaches and lines of marine erosion. The rivers have silted up their lower channels in great measure, but harbours receiving inconsiderable drainage still possess great depths of water. Bridge building operations along the lower Hawkesbury River show a depth of 250 feet at least of shore line submergence. Following one of the typical main water courses inland, the drowned portion is found to end at distances of from 60 to 80 miles from the shore line.[2] Hence the stream rises by slight rapids on to an older valley floor.

At varying distances from the sea a torrent track is entered upon and the valley becomes a profound cañon varying in depth from 1,000 to 4,000 feet according to the plateau traversed. These gorges are generally of "valley in valley" type, and their sides are clothed with dense growths of magnificent vegetation. With progress upstream the gorges are found to end in gigantic waterfalls, the latter sometimes exceeding 1,000 feet in height. Above the waterfalls the thalwegs are confined to narrow and steeply

[1] E. C. Andrews (a). C. Hedley, (d) p. 13.

[2] Following Gulliver in "Shoreline Topography" the shoreline is here considered as the intersection of the planes of the sea and the land.

inclined valleys, but these features pass quickly upstream into shallow mature valleys. Such a valley upon examination is found to be enclosed within another shallow but broader mature valley. From the valley divides, the country around is observed to consist of numerous "valley in valley" forms similar in appearance to the one just vacated, the inter-valley ridges rising to the same general height and thus giving the appearance of a maturely dissected peneplain. Sometimes the valleys are so broad and shallow that one peneplain surface appears to have been excavated out of another. Above these again rise many residuals with which again are associated large and higher fault blocks, whose surfaces are similar to those of the lower plateau blocks just described. At an earlier stage of the inquiry into the origin of the plateaus, some of these faulted masses were considered at times as older peneplain surfaces.

An important fact may be stated at this stage, namely, that the Main Divide has been determined in the main by the position of the Pleistocene horsts. This fact will receive fuller discussion later.

After crossing the Main Divide the western aspect of the plateau is entered upon and after traversing the unreduced plateau masses for considerable distances the thalwegs are observed to become suddenly steep; cañon in cañon forms are entered upon; the plateau becomes dissected by a network of ravines, the valleys grow broader; the mountain piles become separated more and more and dwindle away into insignificance, until they disappear under the sea of alluvium which constitutes the Black Soil Plains.

A peculiar feature of some of the cañons of the western slopes of the Victorian and southern New South Wales mountains is that their bases are deeply alluviated.

(a) *The Hawkesbury.*—This stream is about 330 miles in length; its eastern course is only about 40 miles in length, and for the greater portion of its length the stream maintains a course parallel to the coast. From its source it flows for some distance on a broad plain or valley about 2,000 feet in height. This valley may be seen stretching to the north far beyond Wollondilly and the Bullio Trigonometrical Station toward Burragorang. At Bullio the plain is 2,500 feet in height, and the southern continuation of the Jenolan horst forms the western wall of the great upland valley or plain. Near Wombeyan, however, the river has entrenched itself in the upland valley to the extent of 2,000 feet or more. The northerly course of the stream is continued through the Hawkesbury sandstone plateau and alongside of the monoclinal fold of the Blue Mountains described by David.[1] Older river gravels may be seen on the escarpment. Near Penrith the river leaves the sandstone in a deep V-shaped notch, and enters upon the Emu Plains and the Wianamatta shales. At this point the river is only a few feet above sea level. After hugging the fold just mentioned for some distance the stream suddenly leaves the low-lying Emu Plains and enters a dense sandstone plateau about 700 feet in height. This it traverses in a defile. It is just after disappearing into this mass that the remarkable bend of the river is entered upon, by which it alters its long northern course for an eastern one. During the whole passage of the sandstone plateau the base of the river valley is submerged. The cañon in places appears to be of the "valley in valley" type.

Remarkable as this bend of the lower river appears to be, it is still more so when considered in conjunction with the associated topography. Thus the flexing action which resulted in the formation of the monoclinal fold of Lapstone

[1] T. W. E. David, (d)

Hill was accompanied by a warping of the plateau to a height of less than 300 feet at Sydney, while to the north and north-west around the lower course of the river the plateau was carried to a height of over 700 feet. Southward also the plateau was rapidly carried to a height exceeding 2,000 feet. Moreover this lower central portion was composed in the main of soft Wianamatta shales, while the more uplifted masses consisted of heavy and dense sandstones.

Another point of interest is that the monoclinal fold is almost intact. Its mass has not been severely breached as yet, except where large watercourses cross its line of direction. The small trench (Knapsack Gully) crossed by the western train in ascending the scarp between Emu Plains and Glenbrook, gives a good idea of the extremely youthful stage of its dissection.

Significance.—The late and Post-Tertiary history of the Hawkesbury River appears to have been as follows:—

A peneplain was developed in eastern Australia in Tertiary time. The Pleistocene was ushered in (as shown in a previous chapter) by flexing and folding and a great coastal strip was faulted and flexed parallel to the shore line. Against the eastern wall of an upfaulted block to the west the river was drawn and at the same time it commenced to cut its way into the rising ground. Along the lower 100 miles of its course it appears to have had a similar course in the late Tertiary to that which it possesses at present, and as the land was warped athwart its course the river maintained its channel against the rising ground. Had this not been the case, the stream must have surely found its way down the warped surface to Sydney. Another explanation, which may suggest itself, of this remarkable action of the river in facing a great dense sandstone plateau instead of flowing to sea by way of Sydney is that the stream

channel was locally warped below the Sydney level, and thus was forced to enter the eastward flowing Hawkesbury. Even in that case the river must have cut its eastern cañon as quickly as the land rose against it, otherwise it would have formed a lake entering the sea near Sydney.

This brings us also to the nature of the movements of the Kosciusko Period, namely, a slow and intermittent one whereby strong rivers could hold their own courses against gentle uplift and thus be rejuvenated from time to time. It is not certain that this "Plateau Period" is yet finished. Certain it is that a pronounced submergence of the coast has taken place within the Human Period, that a slight elevation has again been imposed upon the submergence and that at present a period of stable equilbirium appears to be in progress, but the whole topography points to the conclusion that the great Plateau Period is not yet complete.

The Snowy headwaters.—The Snowy has a great north and south course from Kiandra past Kosciusko and Jindabyne. Thence past Dalgety it wanders away from a meridional direction for many miles only to return to the north and south course which it thence maintains to the sea. If we consider the Eucumbene as the main Snowy (which indeed it is when geographically considered, because the channel bàse of the Snowy is hung above that of the Eucumbene at their point of junction) it is seen that the Snowy heads in a faulted plain 5,000 feet above sea level. The Murrumbidgee lies in the northern continuation of this fault block but a cross fault has re-adjusted the catchment areas of the two streams. At Kiandra the Snowy flows through a narrow gorge which enters the plateau of the Rocky Plain and Paradise Flat some miles lower down stream.[1] The depth of this young gorge is a measure of

[1] Süssmilch, C. A., (a) pp. 337, 338.

the amount of faulting from Kiandra to Paradise Flat and also of the recency of such action. Under Kosciusko the river flows in a peculiar and flat-floored valley. The latter is hemmed in to the west by the mass of Kosciusko whose summit rises 4,300 feet above the Snowy valley floor. Through two profound cañons the Thredbo and the Snowy of the maps leave the mountain pile of Kosciusko and enter the curious and broad flat-floored valley under discussion. Eastward the valley rises steeply to the Monaro level and the valley side is trenched here and there with tiny cañons which reach the Snowy valley as cascades.

Rising ground appears to block the river below Jindabyne but in reality the stream pierces the obstacle by means of a gorge. Alluvial terraces[1] in the broad valley floor indicate a tiny lake only just drained by the deep gorge which has almost reached Jindabyne. The trench deepens down stream and pierces a large fault block forming a wall to a broad and high senkungsfeld (3600 ft.) now drained by the Mowamba. From the lip of the ravine by which the stream traverses this range, the country may be seen to fall away steeply to a low lying plateau surface at Dalgety. Thence the Snowy may be seen approaching a great mountain pile (fault block) to the south, which it penetrates in turn in profound ravines.

It would thus appear that the course of the Snowy has been much altered by the activities of the "Kosciusko" Period. Great block faults have been thus formed in the Snowy River district. Such faulting has been described in part also by David and Süssmilch.[2]

The Snowy River valley thus appears to be a fine senkungsfeld with a tilt in an upstream direction, and the Dalgety

[1] See also David, T. W. E., (c) p. 666.

[2] David, T. W. E., *loc. cit.*, pp. 657 - 668. Süssmilch, C. A., (a) see literature.

Plains appear to be faulted off both the Monaro block and the mountain masses to the south of Dalgety. The recency of the faulting is shown by the cañon growths. The head Snowy has not receded in cañon form to the Main Divide through the Kosciusko block. Moreover the lower river has not yet cut its cañon to Dalgety; neither has the stream above Dalgety yet quite cut its way from the Dalgety block to the Jindabyne senkungsfeld, while the tiny streams traversing the eastern wall of the senkungsfeld have only succeeded in notching the edge of the escarpment. The slowness of the warping movement is indicated by the absence of traces of an important lake at Jindabyne, which must have existed[1] if the river had not maintained itself against the uplift from Dalgety to Jindabyne.

In concluding this chapter it may be stated that the Murrumbidgee, Shoalhaven, Macquarie, Clarence, Barron and other streams will be found to yield life histories as remarkable as those of the Snowy and Hawkesbury.

Summary of Valley Topography.—It will thus be seen that Eastern Australia has a series of highlands arranged along its periphery and "curving sympathetically" with the coast line. The bulk of these mountain blocks are due to to faulting and the blocks so raised are dissected by deep gorges. The surface topography of the various blocks is similar, although they are separated by immense scarps. If the ravines [which cause the plateaus to be almost inaccessible] could be filled again with rock material, and if, moreover, the flexed and faulted blocks could be let down into the positions they occupied prior to the flexing and faulting action, then we should have the appearance of a peneplain mildly roughened with broad shallow valleys and dotted over with isolated residuals of an older peneplain surface.

[1] See however David, T. W. E., (c) p. 666.

With regard to the altitude at which this peneplain was formed, we know that wherever one now finds a plain near the seaboard in eastern Australia elevated even a few hundred feet above sea level, one may also find ravines traversing that low plateau. It is a safe conclusion then that the peneplain of eastern Australia which existed immediately prior to the Kosciusko Period was formed at a height not much above sea level.

As to the age of the present mountain systems of eastern Australia one can see at a glance that they are only as old as the gorges which dissect them. From palæontological and mechanical considerations these are almost certainly not older than the close of the Tertiary or the commencement of the Pleistocene Period.

By the faulting and flexing action of the Kosciusko Period certain streams were forced to take up meridional courses. The movement was slow because strong streams were able to hold their own against the uplift. In the Human Period a general submergence of eastern Australian coasts took place and by this movement a series of magnificent harbours came into being.

(B) The evidence of the Leads of the "Newer Volcanics." Under the previous sub-heading a general statement of the topography of the plateaus was supplied. Nevertheless there are many important details which modify this general description. Thus it has been shown that the main outlines of the upland topography have been formed out of Pre-Tertiary rock structures. The old plateau surface, however, is capped in places with wide sheets of basaltic lava, which in turn overlie "deep leads," (that is buried river deposits). These deep leads occupy definite channels, and they belong to two distinct periods of deposition.

"Deep leads" of still more recent age occur under thick masses of alluvium formed in the embayments of the Great

Black Soil Plains. These "leads" of most recent age are characterised by the presence of Myrtaceous trees, of Banksias, of Casuarinas, and by other plant forms almost indistinguishable from the present day vegetation. The younger "leads" of the Pre-Kosciusko Period are capped by basalts and their floras are quite unlike those to be found in Eastern Australia at the present day. The "Leads" occur frequently in regions possessing a rigorous winter climate, nevertheless the plant remains contained in them find their nearest analogues in the tropics.

The oldest of the "leads" also exist under basalt coverings on the plateau and are characterised by floras quite unlike those of the younger "deep leads," or of those of the present day. Lauraceous leaves and leaves of *Salisburia* are common. The "leads" only of the second period, however, are here considered in detail, the earlier Tertiary history of Eastern Australia being reserved for a later paper. Several points of importance in connection with the late and post Tertiary history of Eastern Australia may be gathered from a study of these "leads" of the second period.

(a) *Distribution of "leads."*—By the geologists of Victoria these leads are known as those of the "Newer Volcanic Period." They have been described from Tasmania, from Ballarat, Daylesford, Gippsland, Orange (Forest Reefs), Gulgong, New England, and the Darling Downs; while "leads" of similar appearance and under similar basalts, but without the definite and characteristic flora of the newer volcanics, have been described from the Cairns district in north Queensland, by Jack and Etheridge (pp. 582 – 588). Their distribution is therefore all along the eastern side of Australia.

(b) *Geology of the "leads" of the "Newer Volcanic" Period.*—In every instance the leads are auriferous. The buried deposits lie in definite channels, the rims of which,

however, they overflowed at times. The thalwegs of such buried channels are fairly steep, and the bases of the channels are almost invariably covered with coarse quartz pebble "drift." In these "gutters" the principal gold contents have been found. Above the coarse basal drifts lie alternating layers of sand, lignite, clay, and pebbly sands. At times, as at Ballarat, several distinct basalt flows are sandwiched with the clay, sand and lignite layers. At times the upper layers of clay, sand, or lignite spread out almost a mile in width. Above all is a capping of dense basalt.

Detailed descriptions of these leads have been given by the geologists of the Victorian Survey, by Professor David, by Wilkinson, and the writer; especially detailed are the descriptions of David and Murray. The list of the principal publications dealing with the "leads" will be found in the list of literature supplied at the end of this paper.

(c) *Height above sea level of "leads."*—In north Queensland the "leads" occur at heights of several thousands of feet. At the Darling Downs a height of from 1,400 to less than 2,000 feet is noted. In New South Wales the Elsmore Deep Leads are 1,800 feet, Guy Fawkes basalts 4,500 feet, Orange Leads 3,000 feet, and Gulgong Leads 1,400 feet in height. At Ballarat and Daylesford the leads are about 1,300 (?) feet above sea level.

(d) *Amount of dissection of "leads," and of associated plateau and basalts.*—Upon an examination of the plateau surfaces it is noted that the latter have been excavated indifferently in basalts, Mesozoic, and Palæozoic rocks. Upon closer examination however, the fact is revealed that the plateau surface was first formed, that it was then trenched by streams, that these channels were subsequently filled with rock waste, and that the basalts were poured

[1] Murray, (a) p. 129.

over them in turn. The amount of dissection suffered by the basalts is seen to be limited to the excavation in them of broad shallow mature valleys varying from one to three miles in width. Skeats[1] mentions the formation of mature valleys nearly a mile in width in the "Newer Volcanics" of Ballarat.

The cañons of the Pleistocene Period are now busily engaged in sawing their ways towards the "leads." In some cases they have accomplished their purpose. From a study of the basalts covering these leads it appears almost certain that some of the great lava floods of New England belong to the "Newer Volcanic" Period.[2] These are now much dismantled. Broad valley surfaces have been formed in them by stream corrasion, while still later cañons sometimes as much as 3,000 feet in depth have been formed in them. Such are the profound ravines of the Guy Fawkes, Clarence, Bellinger and Hastings Rivers.

(e) *Fossil contents and age of the Leads.—Baron von Mueller.*—The determinations of this eminent botanist[3] have thrown much light upon the flora of the "Newer Volcanic" Period. Through the unceasing efforts of Reginald Murray, Krause, Taylor, Clarke, and Wilkinson, the Baron gradually came into possession of a whole mass of fossil fruits extracted from "leads" in Queensland, New South Wales, Victoria and Tasmania. By the peculiar types of these fruits he was enabled readily to distinguish the leads of the "Newer" from those of the "Older Volcanic" periods, although some of the field geologists themselves had confused the two types of "lead." Von Mueller prepared careful descriptions of the various types. A full list of his

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[1] E. W. Skeats, (a) p. 209.

[2] Older Tertiary lavas occur associated with the "Newer Volcanics," These are subordinate in amount, however, to that of the "Newer Volcanics."

[3] Decades, see Literature.

determinations and a magnificent set of plates illustrating these fossil fruits are given in his First and Second Decades (mentioned under Literature). The conclusion that this eminent scientist arrived at was that these "leads" of the "Newer Volcanic Period" belonged to the Upper Pliocene Period; that the country at that time was much more humid and warm than at present, and that the analogues of these plants must be sought in tropical regions. This conclusion was not based upon a study of foliage alone, but upon well preserved fruits and seeds. All the genera differ from those now living.[1]

Reginald Murray.—Through the geological examinations of Murray additional light was thrown upon the age of the Victorian leads of the newer volcanic period. He points out[2] that the present leads are characterised by myrtaceous remains, the "Newer Volcanic Leads" by tropical plants, and the "Older Volcanic Leads" by the presence of lauraceous leaves. He also points out that if myrtaceous plants had existed in the "older volcanic" period we should find traces of them there as we do in those of the "newer volcanic" period. On page 29 he states that the famous leads of the "Newer Volcanics" indicate a uniformity of physical conditions from Hobart to Brisbane in Queensland. He failed however to understand the significance of these uniform conditions. In his Physical Geology (1887, p. 115), he states that the Pliocene fluviatile deposits appear to be younger than the Pliocene marine, and that followed down to the sea or to the Murray Valley they merge into marine beds. [It may be pointed out here, however, that the present opinion of Victorian biologists is not unanimous as to the age of certain marine Tertiary beds in Victoria].

Murray noted also the wonderful denudation to which the Newer Volcanics had been exposed in the Pleistocene.

[1] McCoy's *E. Plutii* is an exception, so also *spondilostrobus*.

[2] Prog. Report, Geological Survey, Victoria, 1874, p. 28.

[He failed, however, to perceive the denudation they had suffered in the pre-Kosciusko or pre-Plateau Period.] He also points out (p. 129) that in the Lower Pliocene the shore line of Victoria had been depressed and that 1,000 feet of sediments had been deposited; that in the Upper Pliocene the land surface had gradually risen and that the "leads" had been formed. He also apprehended the fact that the present mighty cañons are younger than the Upper Pliocene of the palæontologists of his time.

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It now remains to be seen what light such facts of observation throw upon the late Tertiary and Pleistocene history of Eastern Australia.

Uniformity of physical conditions.—It is evident as a result of an examination of the fossils collected from these "leads," that a mild and fairly uniform climate must have extended right from Hobart to north Queensland in Upper Pliocene time. Incidentally this would imply a non-mountainous country—one possessed of moderate relief only. The excellent descriptions of, and plates illustrating the fossil fruits of the "leads" in Baron von Mueller's reports reveal the fact that the flora of the "Newer Volcanic" period was quite unlike that of the present day in Eastern Australia. His examination moreover reveals the presence of plants in the Upper Pliocene possessing affinities with certain tropical types of to-day, and the characteristic absence of myrtaceous plants and acacias. Furthermore, the typical flora of the coastal area in Eastern Australia to-day is quite unlike that of the present inland area. During the "Newer Volcanic" period this was not so, because the "leads" occur indifferently on both present coastal and inland falls. Such a uniformity of floras, coupled with the fact that the fossils occur in leads now occupying both eastern and western falls of the highlands, points irresistibly to the conclusion that the eastern side of Australia in late

Tertiary time consisted of a slightly roughened surface not raised much above sea level.

It is astonishing that neither Murray nor Baron von Mueller, nor even Sir Frederick McCoy perceived this physiographic fact. On the contrary, Murray states[1] that the mountains from which these streams arose were much higher than those of the present day, and this despite the fact that the surfaces on which the "leads" occur are trenched by profound and almost impassable cañons.

This statement of Murray brings us to the physiographic significance of the "leads." In each case their channels may be seen to have been excavated rapidly in a peneplain surface. This is evident from the nature of the surrounding topography, [seeing that the leads, as stated also by Murray, occur on the summits of the highlands] and from the nature both of the channels and the coarseness of the "gutter" wash. It has also been stated by Murray and others that these lead channels marked a long period of deposition extending in some cases from Miocene to Upper Pliocene. This is difficult to understand. Such channels as are occupied by the leads under consideration are of ephemeral duration, and must either become rapidly buried or enlarged, as they could not resist the forces of erosion for any but the briefest geological or geographical division of time if exposed to the full force of erosive activities such as occurs along any steep channels. These points, however, will receive fuller discussion later.

The fact that these "leads" and these basalts have been trenched in places recently by gorges several thousands of feet in depth, points irresistibly to the conclusion also that during the "Newer Volcanic" period the land must have been near to sea level. For example, the plateau carrying the Kiandra "lead" (4,700 ft.) is trenched by the Tumut,

[1] Physical Geology, p. 124.

which is only 900 feet above sea level a few miles away. The Tumut gorge near Yarrangobilly exceeds 3,000 feet in depth. Similarly for the New England, the North Queensland, the Darling Downs and the Victorian districts. The depths of these cañons are a measure of the amount of uplift of the land since the leads were formed. Had modern physiographical methods been known to such men as von Mueller and Murray they would have solved the problem of the Pliocene and Pleistocene history of eastern Australia easily, instead of being bewildered by the evidence.

To return to the main discussion it may be noted that the leads distinctly point to a rapid period of subsidence during their formation. For stream activities either aggrade or corrade channel structures, they cannot fail to influence them one way or the other. We know that when earth material is dragged over other earth fragments a mutual loss is sustained in volume. A stream then when armed with a load of stones and sand, must wear away any point of the channel base or sides along which it flows, so long as it is able to move its load of débris as a whole over the point in question. On the other hand, as soon as the stream becomes incompetent to move its load, as a whole, over any particular point of its channel, it becomes unable to cut into the channel structures at that point, because some of the material falls out onto the channel surface there, instead of being dragged over it and thus actually protects it. That is to say, the stream will fill up its channel there with débris instead of cutting the channel deeper. This is what happened all over Eastern Australia during the formation of these leads. The peneplain had been moderately elevated, channels were then rapidly excavated in its surface as shown by the form of the channels and the nature of the "gutter" wash; subsidence then set in with the gradual filling of the channels. The

varying nature of the subsidence is shown by the alternation of sands, clays, and lignites in the leads and the fact that the basalts of the Newer Volcanics were poured out during the sinking movement, is shown by the occurrence of basalt flows both above and between the "lead" deposits as at Ballarat.

Age of the Leads of the "Newer Volcanics."—The age of these continental deposits has been given as Upper Pliocene by such eminent authorities as McCoy, von Mueller and Murray, because of the position they occupy with respect to certain marine strata supposed to be Upper Pliocene, and also because of their superior position to certain so called Miocene marine beds. As stated in a previous chapter, there appears to be some conflict of opinion among Victorian biologists as to the exact age of certain marine beds of Tertiary age which are inferior to the "leads." Under these circumstances it may be advisable to institute a physiographic comparison between the Pliocene and Pleistocene corrasive activities in North America on the one hand, and the work supposed to have been accomplished in Eastern Australia in similar periods on the other hand. In this way some light may be thrown on the problem of the age of the "Newer Volcanics" and their subjacent "Leads."

In Eastern Australia we have evidence of a moderately raised peneplain, on whose surface deep "leads" were formed during a later subsidence. Basalts then deluged this area, and still later, stream activities dismantled the great basalt flows and induced sets of very broad shallow valleys in them. Then came the great revolution in the topography when the "leads" were hoisted for thousands of feet above their former positions, when the plateaus were heavily faulted and flexed, and later still the profound cañons of Eastern Australia were formed.

Along side of this we may place the accounts of Pliocene and Pleistocene history in North America as interpreted by American authorities. Among American authorities the Ozarkian or Sierran Period is considered either as the close of the Pliocene[1] or the commencemnt of the Pleistocene.[2] Le Conte and others favoured a Pleistocene age for it. According to these authorities a study of Western North America points to the conclusion that (1) during the Pliocene, wide valleys almost of peneplain dimensions in places were formed along the Pacific area, that (2) at the close of the Pliocene an enormous uplift and faulting movement took place, and that (3) the profound gorges of the Sierras, of the Rocky and Selkirk Mountains, and of the Colorado Cañon of Arizona were the work of Sierran (Pleistocene) activities.

If we now look at this from a broader or "Pacific" point of view it will be seen that physiographically our "Newer Volcanics" may be placed in the Pliocene. The Eastern Australian coast is roughly of the Pacific type; it borders the Pacific, while the stage of dissection of both the "Newer Volcanics" and of the associated plateau surfaces is similar to that assigned to late Pliocene activities in Western North America. The Kosciusko period[3] also presents great similarities to the Sierran Period in America, and the later stage of plateau dissection arrived at by each area is almost identical. Even the subsidence during the Human Period for each area is similar in appearance. It would appear in fact that "Pacific" conditions obtained during the Pliocene and Pleistocene periods.

Conclusions.—It will now be interesting to discuss briefly the physical and biological significance of the late and Post-Tertiary activities in Eastern Australia.

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[1] Journal of Geology Vol. XVIII, 1910, No. 3, p. 227.
[2] Chamberlin and Salisbury's Geology, Vol. III, pp. 311 - 318.
[3] Believing that "Diastrophism is the true basis of correlation" the writer regards the "Kosciusko Period" as the movement which closed the Tertiary and ushered in the Pleistocene.

(A) Physical Significance.

It will be advisable here to briefly summarise the main topographic features of Eastern Australia and to ascertain their relationships to the topography of the associated regions.

Eastern Australia consists of an inland, a highland, a coastal, and a continental shelf area. Each is roughly parallel to the coast line, and each presents a convex front to the Pacific Ocean. The Victorian Alps lag several hundreds of miles behind the apparent motion of the Queensland and New South Wales highlands towards the Pacific. The highlands have been formed by the irregular uplift of a peneplain during the movement which closed the Tertiary time. The plateaus fall away in terraces, in senkungsfelder and in flexes to the continental shelf. Extreme youth characterises the highlands because of the undissected state of their great central masses. The dissection of large upfaulted blocks in the central highlands is incomplete, and the complete dissection of the plateau, even by cañons, is still far away in time. Thus the Snowy drains several distinct faulted blocks, and each block serves as a temporary base-level for the drainage of the associated upfaulted mass. The faulted Kiandra block is dissected by a cañon while the down-faulted plateau to the immediate south is still undissected. Smilarly the upfaulted mass of Kosciusko is pierced with cañons which open out on to the undissected Jindabyne senkungsfeld. The Dalgety plateau is still undissected, but the uplifted block to the immediate south of Jindabyne is partly dissected. The profound gorge of the Snowy is still far south of Dalgety. Until the Snowy shall have eaten back from Dalgety clean through the Kosciusko block, the dissection of the plateaus will be only in its early stages.

The age of this grand movement has been assigned to the very close of the Pliocene, both on account of the fossil evidence, and on account of the striking analogies to be found in the Ozarkian or Sierran Period in Western North America.

Areas associated with Eastern Australia.—New Guinea, Gilolo, Australia and Tasmania are all connected by a shallow sea less than 1,200 feet in depth, while Ceram, Borneo, Celebes, Timor, Java, and Malayasia generally lie on a shallow shelf separated from Australasia by a narrow sea varying from 1,200 feet to 12,000 feet in depth. If one now considers the ocean area to the east of Australia, it will be seen that several distinct lines which curve sympathetically with the coast line of Eastern Australia pass through New Guinea, New Caledonia, Fiji, New Zealand, and other islands. In New Zealand itself one sees a relation to that of the south-eastern curve of Australia. These island curves have been discussed in recent literature by Hedley[1] and Taylor.[2] Oceanic deeps also parallel these curves. The main point for our purpose is first, to notice the connection of these curves to each other, and secondly to ascertain their relations in time, because on such perception depends in great measure the determination of the geographical distribution of animals and plants in Eastern Australia.

From mechanical considerations it is at once evident that they are related in space if not in time. The convexity of all to the Pacific, the sympathy of curvature of each, and the parallelism of each to the associated oceanic deeps are very pronounced.

The first thing which strikes the observer is that each uplifted mass is not folded as in a scheme of typical moun-

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[1] Hedley, C., (a), (b), (c) and (d).

[2] Taylor, F. Bursley, (a) p. 212 – 214.

tain crumpling, but each has been raised bodily without visible flexure of the rock dips. The main Australian uplifts have not altered the dips of the Triassic and Permo-Carboniferous rocks to a greater extent than one degree.[1] In Fiji, Tonga, and other islands, the uplifts have been vertical. In New Zealand also the great height of the Alps is the result of vertical uplift to form sub-horizontal plateaus. Descriptions of New Guinea, Java, and Timor, indicate that such also has been the case in those regions. The stage of plateau dissection attained by the streams of New Zealand, Tasmania and other places in this Australasian region is almost identical. In the case of New Zealand the streams have breached the Main Divide in places, but this later youth of dissection is due to the accentuation of erosive activities by the greater uplift of the land, the short steep runs of the streams to the sea, the enormous amount both of precipitation and of erosive action of the late Pleistocene Glaciers. Descriptions of New Guinea topography by Mr. C. Hedley during conversation with the writer also indicates that this enormous island was uplifted during the "Kosciusko" or "Plateau" Period of Eastern Australia.

It will thus be seen from mechanical considerations that at the close of the Tertiary Period the whole of Malayasia and the Great Australasian Region were elevated, the Malayasian area along one set of curves[2] and the Australasian along another. At an earlier period an actual formation of Alpine chains by the compression of strata occurred in New Guinea, Fiji, New Zealand and other places along the lines of the present mountain ranges, but the highlands of to-day owe their existence to faults and gentle warpings, which although only of very small

[1] See also Carne, J. E., Kerosene Shale Deposits and Western Coalfields of New South Wales.

[2] See also F. B. Taylor, (a) pp. 192 - 195.

angular value nevertheless were productive of great elevations[1] and depressions.

By a conflict of the Australian and Malayasian earth forces it is probable that the two regions of these names were still more separated than they had been in late Tertiary time. At the time of this uplift New Guinea and Tasmania appear to have become separated in part from the mainland by heavy faults, and by a much more recent movement they have become well detached from Australia.

It now remains to be seen what may be learned from the facts as to the relative rapidity of this motion and its cause.

Rate of Plateau formation and later movements.—That the warping movement was relatively slow is apparent from the fact that strong streams such as the Lower Hawkesbury were enabled to hold their own against the uplift. Its limitations are seen however by the fact that when the faulting was very decided, the streams could not keep pace at all with the rate of uplift. Thus the strong Barron, Tully and Johnson Rivers in North Queensland have not been able to keep pace with the uplift, but have only recessed the very front of the uplifted block in that region. In Kosciusko the Snowy has not yet cut its cañon clean through the uplifted fault block, nevertheless the Snowy here is a strong stream. Similarly for the Eucumbene at Kiandra. The slight gorges only which notch the monoclinal fold of the eastern Blue Mountains at the points where it is traversed by weak streams, evidences the youth of this feature. The fact also, that the most powerful streams have not yet eaten into the Divides, also evidences the relative rapidity of the uplifts. It was only at certain

[1] The Western Mountains of North America and the Alps of Europe appear to be examples also of this recent vertical movement. The Great Arizona Plateau is a fine example of such action.

spots of slight uplift and strong stream action that the streams held their own against the upward movement.

The submergence which formed the harbours is seen to have been rapid in action owing to the unsilted condition of inlets of the Port Jackson type. By this action also the continental shelf was widened, and the shore line carried westward. The edge of the continental shelf was thus deeply drowned. This later submergence it was which perplexed the early observers as to the nature of the origin of the Continental Shelf.

Cause and nature of movements.—It has been pointed out already that the movement, although one of flexing, was not of such a nature as to compress the rock structures with the formation of mountain ranges, but rather that it was of the nature of a very gentle warp broken by faults which produced the effect of vertical uplift when viewed as a whole.

It now remains to be seen what evidence is at hand by which the motion may be explained.

Hedley[1] considers the convex Australasian curves as being direct thrusts from the Pacific area. In this he is in agreement with Professors Haddon, Sollas and Cole who[2] "distinctly see in Australia and its islands" . . . . "the vast folds of the earth's crust roll slowly inwards upon the central continental mass."

This view as stated appears to involve certain dynamical difficulties. For example, if a thrust from the Pacific be considered as rolling directly against the continental mass above ocean base, then one would expect the fold curves to be concave to the Pacific. On the contrary they are convex. On the other hand if one imagines the periphery

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[1] Hedley. C. (d) pp. 17 - 19.

[2] Trans. Roy. Irish Academy, xxx, 1894, p. 473, Quoted from Hedley (d) p. 18.

of Australia to move eastwards and radially toward the Pacific from a "negative" central area, such as Suess has shown for Eurasia, then we may imagine the continental margins as being overthrust against a great sub-oceanic creep and the convexity of the continent to the Pacific is understood.

In this method the Pacific would be considered as a sinking mass which produced lateral thrusts at a depth towards the continent, while at the same time there was a backward superficial thrust of the continental shell over the mass slowly advancing below the ocean floors. An able and simple statement of the main mechanical principles involved in such action is supplied by Chamberlin[1] and Salisbury. This also is the principle insisted upon by Bailey Willis in his later writings.[2]

But as will be shown anon, the presnt New Zealand Alps and the Australasian mountains are not of the compressive (folded) type, but are merely plateaus of the Arizona and Californian or Tibetan types.

There are moreover other points to be considered. The centre of Australia has been a "negative" or sinking area during various geological periods, while Western Australia has been a horst[3] during the greater part of geological time. The southern periphery of Western and South Australia is concave to the Southern Ocean, while the neighbouring Jeffreys Deep is subparallel to this coastline. The north-eastern portion of the Western Australian horst is now a plateau of 4,000 feet in height (Arnheim Land and the McDonnell Ranges). It must not be forgotten, moreover, (see Fig. 1) that the Australian highlands make a remarkable curve from the east to the north at the heads of the Murray, and that Bass' Strait and the northern face of the

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[1] Geology, Vol. III, pp. 526–529. [2] Principles of Palæogeography.
[3] See also Gregory, J. W., p. 92.

Tasmanian plateau appear to be dynamically and directly related to the Victorian highlands. These Australian plateaus moreover fall away in parallel flexes, terraces and senkungsfelder to the continental shelf and thence are more rapidly flexed to oceanic depths. New Zealand on the other hand presents its steeply faulted and flexed front to Australia. This appears to be the case also for Fiji and New Caledonia,[1] where the low eastern island groups are associated with much higher land masses to the immediate west.

Taylor's idea of the Australasian development in late Tertiary time is that a force acted from the Antarctic region towards the north-east probably carrying the continent bodily with it from the Antarctic direction.[2] Taylor, however, was unaware of the peculiar and peripherally arranged highlands of Eastern Australia and of the peculiar relation Tasmania bears to Victoria.

If one considers the peculiar and almost concentric arrangement of the topographic divisions in Eastern Australia, it will be seen that the bulk of the interior has been a sinking area (now a great artesian basin 600,000 square miles in area), and that from it as a centre the rings appear to have gained in height[3] until they fell in terrace form to the oceanic depths. This gives rise to the idea that from the inland portion forces have been directed to the periphery.

All previous observers appear to have overlooked the fact that the Australasian and New Zealand mountains are those of vertical uplift and not of compression. Isostatic readjustment between large "negative" and "positive" elements appears to have formed these plateaus and magnificent faults.

[1] See also Hedley for New Caledonia (d) p. 18. [2] Taylor, F. B.,(a) p. 212.
[3] Excepting on the western aspect of the Alpine knot.

The Australian Alpine knot is just the topographic feature which might be expected from this assumption. Thus Tasmania and the associated continental shelf formed a horst against which the southern forces were delivered from the centre and the Alpine knot would result from the interference both of the horst and of the strong suboceanic forces from the Southern and South Pacific Oceans.

In this interpretation the main forces are considered as coming from the Antarctic and south-eastern oceanic areas and the minor ones as coming from the central "negative" (dense or sinking) area to form a reversed overthrust towards the oceans. The influence of the Tasmanian horst is seen on the Victorian highlands; the direct influence of the Antarctic thrusts on the West Australian horst is seen in the concave curve of south-western Australia and the associated Jeffreys Deep and the heights of Arnheim Land and the McDonnell Ranges appear to be arranged on the eastern margin of the great Westralian horst, a horst which may be seen to have formed a "positive" (buoyant) element since Archean time.

The discussion of the outer Australasian arcs is not here considered. Fig. 1 illustrates a scheme of forces which appears to accord with the facts of observation.

Great Barrier Reef and Harbours.—The Great Barrier Reef was initiated by the activities of the Kosciusko Period which resulted in the submergence of the late Tertiary shoreline. The continental shelf thus appears to represent a strip flexed or faulted below sea level. In North Queensland the submergence doubtless was caused by faulting. Coral growths attached themselves to the sinking shoreline in the Queensland area and formed a great barrier reef. During the more recent submergence the shore was still farther depressed, and the Barrier Reef increased in width and depth until it attained its present portions. The

reefs lying inshore along the North Queensland coast line belong to this more recent phase of Barrier Reef formation. Previous to this land submergence during the Human Period the shoreline of Eastern Australia was a monotonous feature unbroken by inlets and quite unfitted for navigation.

Black Soil Plains.—These form a great topographic feature which has been determined in great measure by the waste derived from the mountains of the Plateau Period. (Both these and the associated waste slopes of the inland are to form the future granary of Eastern Australia.)

Earthquakes.—The area in the neighbourhood of the greatest faulting is the scene of mild but frequent earthquakes. This earthquake zone lies in the Australian Alpine knot and in the Adelaide region.

(B) Biological Significance.

The briefest mention only is here made to the relation of the geographical distribution of plants to the physiographic changes in Eastern Australia, inasmuch as the subject will be dealt with at length at a later date by Mr. R. H. Cambage and the writer.

Botanists of Eastern Australia have been perplexed over many points in the present geographical distribution and the life histories of plants belonging to this vast region. A few examples of such difficulties may be here presented.

(1) *Variable floras of late and post Tertiary time.*—This subject has already been discussed under the head of "The Evidence of the Leads."

(2) The present flora of the coastal area is quite unlike that of the area west of the divide in general appearance, whereas the flora of the period immediately preceding the Kosciusko Period appears to have been fairly uniform over Eastern Australia.

(3) Difficulty is experienced at times in attempting to separate certain allied species of eucalypts and acacias which may exist in neighbouring regions separated by a natural barrier.

(4) Certain eucalypts and acacias possess seedling and adult forms so unlike as to cause the diverse forms exhibited by the same plant to appear as distinct species. A significant point in this connection is that the eucalypts which exhibit this peculiarity are mostly, if not entirely, confined to the highland and coastal region.

(5) Certain isolated plateau blocks possess species of eucalypts peculiar to themselves.

(7) Certain eucalypts occur only in isolated patches along the Eastern Highlands.

No biologist can afford to lose sight of the topographical revolutions at the close of the Tertiary Period. During the Pliocene the evidence points to the existence of a peneplain across Eastern Australia, possessing a mild and fairly uniform climate. In the same period came the formation of the "lead" channels, and later again came the subsidence and burial of these channels with waste and with basaltic lavas. To this succeeded the Kosciusko Period, during which time a great system of highlands was developed peripherally to the coastline from Thursday Island to South-western Victoria. The movement was relatively rapid, (see chapter on Physical significance). In no one place was the plăteau less than 1,200 feet in height, while the average height was 3,000 feet, and immense blocks of meridional disposition from 4,000 to 7,000 feet in height also formed. By this means the coastal area was isolated from the interior. The climate of the eastern fall was rendered more mild and humid, while at the same time the

interior was rendered more arid.[1] The plateau was affected by desolating and cold winds, and the flora of the mild Pliocene was unfitted to populate it.

It will be seen at once that several factors came into operation during this stage. The law of isolation came into full force and the plants were called upon to rapidly accommodate themselves to the new conditions or to perish. Thus, instead of a grand and uniform southern and central Eastern Australia flora as in the Pliocene, three distinct types now exist, namely, a jungle, a plateau, and a desert flora. Along the plateau the southern types must have crept northwards until other natural barriers were set, It must be remembered also that the plateaus underwent refrigeration at a stage much later than the Kosciusko Period, and this most likely induced a further change of habit and form in those eucalypts which had only just accommodated themselves to the plateau conditions in the pre-glacial period.

Summary.

The site of Eastern Australia appears to have been occupied at the close of Miocene time by a peneplain. At a later period the peneplain surface was elevated and definite channels of moderate depth were cut in its surface by the streams. Gold and tin were carried down from the neighbouring hills and deposited in the coarse stream gravels. Valuable "leads" were thus formed. The land then sank and the channels became gradually filled with sand, clay, pebbles, and lignite. Basalts at this stage commenced to make their appearance, and flood after flood of such basic lava buried thousands of square miles of the country. The "leads" thus, in turn, became buried. Erosive

[1] This later aridity is indicated by the peculiar nature of the topography. Mature valleys have been developed in the western rock belts but the rainfall is not now sufficient to keep them open; their bases are alluviated and the streams disappear altogether in the sandy stream beds.

activities supervened and wide valleys or plains were formed both in the basaltic masses and in the associated geological complexes.

The Tertiary closed with a vigorous uplift. Forces appear to have been directed both from Central Australia radially outwards, and from the southern oceanic regions toward Australia. In this way the continental edges were upwarped until incoherence was established. At this stage relief of the marginal strain on the continent was obtained by faulting and flexing in arcs parallel to the oceanic depths. Tasmania acted as a horst, and against it and the suboceanic creep the Victorian mountains and the mountain knot at the south-eastern angle of Australia were formed. In this region the faulting and flexing were most pronounced. For this period of plateau formation the name "Kosciusko" or "Plateau" Period is suggested. It may be mentioned here in passing, that this southern portion of the continent has had much more vigorous oscillatory movements in a vertical direction since early Tertiary time than have other portions of the eastern continent.

The rate of movement vertically was not rapid. The Lower Hawkesbury appears to have kept pace with the uplift, but at a distance from the shoreline area the streams failed signally to do so. The plateaus indeed are still undissected, excepting on their western and eastern margins. The great fault blocks also have been only partially dissected by headward working streams.

Toward the close of the "Kosciusko" Period the upward movement was rejuvenated and "valley in valley" forms now characterise the valley bases.

After the great faulting Period great basaltic displays appear to have taken place in Victoria, Tasmania, Queensland, and probably also in New South Wales.

The eastern portion of the continental shelf was formed during this period, first by flexing, and secondly by erosion and sedimentation. The Great Barrier Reef was also outlined at this stage.

The inland and coastal areas became isolated from each other by the formation of the Plateau, and the old uniform flora was replaced by types distinct from each other and from the flora of the pre "Kosciusko" Period.

Malayasia appears to have been separated from Australia and New Guinea during an earlier period, while New Guinea and Tasmania appear to have been separated from Australia at the commencement of the "Kosciusko" Period. A stream of New Guinea life had entered Australia previously from the north, and a stream of Antarctic life had entered Australia by way of Tasmania. It is probable, however, that in both cases the isolation was not at all complete until the submergence during the Human Period.

After the Kosciusko Period (close of the Tertiary) was well spent, the Glaciation of Kosciusko, of the Fainter High Plains (?) of Victoria and of Tasmania occurred. A phase of coast submergence was ushered in at a still later period, and to it are due both the present form and the width of the continental shelf, as also that of the Great Barrier Reef of Queensland. The harbours of Eastern Australia, as also the complete isolation of New Guinea and Tasmania from the mainland are due to this movement.

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In this late and post Tertiary history of Eastern Australia, one important fact stands out, and that is the geographical unity of the Eastern continent.

(i.) The Tertiary peneplain extended from north to south across the continent. The flora was uniform and evidenced a mild to tropical climate.

(ii.) The "leads" of the Pliocene, or of the "Newer Volcanics," are to be found all along the eastern continent. They all evidence similar floras, and they all evidence subsidence accompanied by filling of the channels by similar continental deposits and a final burial under floods of basaltic lavas.

(iii.) The basalts of the "Newer Volcanics" are similar in appearance along the whole eastern side of Australia.

(iv.) The "Kosciusko" Period is also noted for its production of similar topographic features extending from north to south of Australia. So also are its rejuvenation phases.

(v.) A similar geographical unity characterised the movements of the Human Period.

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Reference should be made here to the Presidential Address of Mr. Charles Hedley to the Linnean Society on March 29th, 1911. In that address, the peculiar marginal drainage of Australia is referred to a folding movement, which came from the oceans. The movement is considered as compressive rather than one of isostatic readjustment.

Appendix I.

List of some important FAULT SCARPS and SENKUNGSFELDER in EASTERN AUSTRALIA.

The subjoined list is not at all exhaustive, only a few of the more important uplifted and downthrown blocks are enumerated. The amounts of vertical displacement furnished are only approximate. Attention is here merely directed to these important features in order that they may be critically examined. Nos. 1, 3, 7, 16, 26, 32, have not been yet definitely proved to be faults.

Name of Fault System.	Locality.	Uplift, Senkungsfeld or Downthrow.	Amount of vertical displacement.	Remarks.
(1) Bathurst	Bathurst (N.S.W.)	All	1,200 ft. maximum	Mr. C. A. Süssmilch is examining this area and his results will be awaited with interest.
(2) Bellenden Ker	North Queensland	Uplifted block	Very large	An element of the Great North Queensland coastal scarp. A mountain 5,000 ft. high here presents a precipitous scarp to the coastal plain.
(3) Bogong	Victorian Alps	Uplift	Very large	Scarp several thousands of feet in height. Downthrown block heavily aggraded.
(4) Buffalo	Victorian Alps	Uplift	Very large	Summit of block 5,600 feet high Country beneath to north-west less than 1,000 feet above sea level. Downthrown or flexed block heavily aggraded.
(5) The Bulldog	North-eastern New England (N.S.W.)	Uplift	Very large	2,000 feet.
(6) North Queensland Scarp	Lucinda Point to n'th of Cooktown (250 miles.)	Uplift	Very large	This may be partly due to flexing

APPENDIX I—*continued*

Name of Fault System.	Locality.	Uplift, Senkungsfeld or Downthrow.	Amount of vertical displacement.	Remarks.
(7) Capoompeta Scarp	Northern New England (N.S.W.)	Uplift	Large	Not yet definitely proved.
(8) Cullarin	Lake George (N.S. W.)	All	400 feet	Described by Taylor.
(9) Dalgety	Monaro (N.S W.)	Senkungsfeld		May be seen from Kosciusko.
(10) Darling Downs Faults	South-eastern Queensland	All	Some very large	Under examination by Mr. R. A. Wearne of Ipswich.
(11) Dorrigo	North-eastern New South Wales	Uplift	Large	2,000 feet (or more) uplift.
(12) Dundahra	Clarence River New South Wales	Uplift	Very large	3,000 feet (or more) uplift.
(13) Mount Elliot	Near Townsville (Q)	Uplift	Large	Mr. W. G. Poole has recently described faulting action in this region. (Aus. Ass. Adv. Sci., 1909.)
(14) Gourock Ranges	Monaro (N.S.W.)	Uplift	Very large	From maps and conversations with J. E. Carne, R. H. Cambage, and others.
(15) Guy Fawkes	North-eastern New South Wales	Uplift and senkungsfeld	Very large	A wonderful view, perhaps unequalled in Australia. The plateau is faulted 5,000 feet vertically to the sea in several steps, the upper scarp being exceptionally large. Although Guy Fawkes is an upfaulted mass on eastern New England and although indeed it is the highest country in Australia north of Sydney, yet the Main Divide lies 50 miles to the west.

APPENDIX I—*continued.*

Name of Fault System.	Locality.	Uplift, Senkungsfeld or Downthrow.	Amount of vertical displacement.	Remarks.
				This arises from the peculiar arrangement of the fault blocks, whereby the western waters escape eastwards through a low part of the fault block.
(16) Harvey and Bumberry Range	Peak Hill, Forbes and Parkes N.S.W	Uplift	Large	Not yet definitely proved.
(17) Kosciusko	New South Wales	Uplift	Very large	From Pretty Point to the Jindabyne senkungsfeld a throw of 3,000 feet in steps (Described by David also by Andrews (f) p. 501.)
(18) Kurrajong	Blue Mountains N.S.W.	Uplift	400 feet	Described by David,
(19) Lapstone Hill	Blue Mountains	Fold	500 feet	Described by David.
(20) Macpherson Range	Boundary of N.S.W. and Queensland	Uplift	Very large	Not examined in detail. Cross faulting.
(21) Monaro	New South Wales	Complex senkungsfeld	Large	Bounded by Kosciusko and Gourock Ranges.
(22) Mooraback	Head of Hastings New South Wales	Uplift	Very large	One of the eastern boundaries of central New England. The country falls thence heavily to the coast. This is the highest portion of the tableland in the district yet the main divide is well to the west.
(23) Mount Lofty Ranges	South Australia	Uplift	Large	Described by W. N. Benson.
(24) Mount Royal Range	South-eastern New England, N.S.W.	Uplift	Very large	Situated at the heads of Manning, Hunter, Patterson and Wil-

APPENDIX I—*continued.*

Name of Fault Spstem.	Locality.	Uplift, Senkungsfeld or Downthrow.	Amount of vertical displacement.	Remarks.
				liams Rivers. Forms an almost inaccessible land area.
(25) Bacchus Marsh	Victoria	Uplift	Large	Not yet examined carefully. It is a dismantled scarp to the north of Bacchus Marsh. Some of the associated basalts are older and some younger than the scarp.
(26) The Nandewars	Near Narrabri and Boggabri N.S.W.	Uplift	Very large	Not yet known definitely as fault or flexure. Most probably a fault. Additional evidence supplied by the great depth of artesian bores at Narrabri and Moree near the bases of the scarps. Great aggradation of the downthrown or downfolded blocks.
(27) Omeo	Victoria	Senkungsfeld	Large	Downthrown block heavily aggraded.
(28) High Country West of Upper Shoalhaven	New South Wales	Uplift	Large	The Shoalhaven here has a long northerly course.
(29) Tasmanian Scarps	Tasmania	All	Very large	*Examples of Tasmanian Scarps*—Ben Lomond, Western Tiers, Mt. Roland, Mt. Wellington, North-East Coast and East Coast,
(30) Tenterfield Area	New South Wales	All	Large	Numerous faults occur in this district to north, south, east and west of town. The Mole River is seen entering a large fault block just west of the Great Northern Line.

APPENDIX I—*continued.*

Name of Fault System.	Locality.	Uplift. Senkungsfeld or Downthrow.	Amount of vertical displacement.	Remarks.
(31) Timbarra	New South Wales	Uplift	Large	Overlooks Upper Clarence 25 miles east of Tenterfield.
(32) Undercliffe	35 miles north of Tenterfield	Uplift	Large	Overlooks Upper Clarence.
(33) High country west of Upper Wollondilly	New South Wales	Uplift	Large	The Wollondilly here has a very long northerly course.
(34) Wooloma Mountain	Upper Hunter (N. S, W.)	Uplift	Very large	
(35) Wanderer Range	New South Wales and Victoria	Uplift	Very large	Curves sympathetically with the associated coast line.
(36) Guyra—Ben Lomond Block	New England, New South Wales	Uplift	Large	The Sydney-Brisbane Mail crosses this at altitude of 4,500 ft.
(37) Murrumbidgee and Kiandra Faults	New South Wales	All	Some large	Described by C. A. Süssmilch. (See Literature).

The writer would also draw attention to the precipitous scarps and the peculiar associated valleys stretching from Bingera to Nundle. At Bingera the powerful Gwydir River breaches the scarp in a deep cañon only. The peculiar "hanging up" of the strong Macdonald River at Woolbrook is also suggestive of a heavy fault. Dr. H. I. Jensen also has mentioned the faults at Sassafras and the associated country. (These Proceedings, 1908, p. 299.)

Tasmania possibly has the finest group of uplifted blocks in Eastern Australia. Ben Lomond, the Western Tiers and the Central Plateau on which the lakes lie are magnificent examples of faulted blocks. Their surfaces are of the ordinary plateau type; they are separated from similar topographies lying at lower levels by immense scarps, and the uplifted blocks are partially dissected by profound ravines.

Appendix II.

The leads of the "Older" and "Newer Volcanics" may be distinguished both by their geographical position and their fossil contents.

(a) *Fossil Contents.*—The Leads of the "Older Volcanics" are characterised by the presence of abundant plant leaves. Among these the lauraceous types appear to predominate in the Victorian area at least. Fruits and seeds are, however, characteristically absent.

The Leads of the "Newer Volcanics" are characterised by the presence of abundant fruits and seeds showing affinities with tropical plant types of the present day. Lauraceous leaves are, however, characteristically absent.

(b) *Geographical Position.*—Leads of the "Older Volcanics." These buried channels usually possess basaltic cappings, and they commonly occur as basalt-capped hills dotting the great Tertiary Peneplain of Eastern Australia. The peneplain has been excavated out of basalts, Palæozoic complexes, and Mesozoic rocks indifferently, and the miners frequently exploit the old leads themselves for their possible mineral (gold, tin and diamonds) contents by means of levels driven in from the hillsides.

Examples.—Dargo High Plains (Vic.); Kiandra, Older Macquarie and Hawkesbury Leads [Mount King George (?), Bald Hills, Hill End, etc.], Older Tingha and Emmaville Leads (N.S.W.)

Leads of "Younger Volcanics."—These buried river channels lie beneath the peneplain surface. They have been buried under basalt floods. The basalts themselves have suffered great denudation and broad mature valleys have been formed in their mass, leaving isolated hills of basalt dotting the rolling surface, due to the post-basaltic erosion, nevertheless the leads themselves underlie the peneplain surface thus made. The leads are exploited by means of shafts sunk either in the peneplain surface or on the gentle hill slopes.

Frequently, however, cañons have been formed in the peneplain and the contained leads. In such cases the younger leads outcrop on the cañon sides and they may thus be won by levels driven in on the hill sides.

Examples.—Tangil, Haddon, Nintingbool, Daylesford, Ballarat (Vic.); Gulgong, Forbes, Forest Reefs, some of the Emmaville and Inverell Leads (N.S.W.); Darling Downs and North Queensland (Qld).

Age.—The Older Volcanics may be Miocene or even Eocene, and the Younger Volcanics Pliocene in age.

THE RESPECTIVE LIMITS OF FEDERAL AND STATE LEGISLATION IN REGARD TO COMPANIES.

By A. DUCKWORTH, F.R.E.S.

[*Read before the Royal Society of N. S. Wales, July 6, 1910.*]

THE report of the Royal Commission on Insurance, recently presented to the Commonwealth Government, contains the results of an exhaustive inquiry by the two Commissioners appointed, into the conditions governing the business practice of life assurance offices in Australia and Tasmania. Its recommendations do not, of course, extend to New Zealand, so that whatever law might be passed in Australia, the Dominion would not be bound by it, and divergences in legislation will doubtless continue to exist. It may be pointed out with some degree of satisfaction that the Commissioners have not in the course of their inquiries brought to light any such abuses as those unearthed by the New York committee of inquiry regarding life offices in the United States in 1906. It is gratifying also that the Com-

missioners, after investigation of the subject, have pronounced in favour of legislation following the general trend of the English Life Assurance Companies Acts 1870, 1872, and 1909. Such legislation, as is well known, has as its basis a full measure of publicity regarding the operations of life offices; rather than that close and direct supervision by the Government which obtains in the United States of America and in Canada. This suggestion will most probably be acceptable to the various offices.

At the threshold of the Commissioners' labours, which were undertaken at the behest of the Commonwealth Government, it was primarily necessary to decide whether Federal legislation should be imposed, such as would effectively supersede the present divergent life Acts of the individual States, and so secure uniformity in legislation, in office procedure, and in the measure of supervision advisable in the interests of the public. It is to this particular initial aspect of the work of the Royal Commission that attention is invited in this paper. The Commissioners state in their recommendation, No. 1, "That in the interest alike of the life offices and the public, it is desirable that the independent legislative provisions of the several States relative to the transaction of life assurance business should be superseded by the enactment of a uniform Federal law." It may perhaps be unfair to assume that the Commissioners intend to convey by this recommendation the idea that all State laws relating to life insurance contracts and business may be thus superseded. They are, of course, aware of the series of judgments which have already emanated from the Federal High Court, either checking, or amending in certain important aspects, Federal enactments which that Court has decided contravene the sovereign powers of the individual States. The Commissioners' recommendation, No. 4, is that "A Federal public officer should be appointed, to

be known by some such title as the Commonwealth Insurance Commissioner, and that every company at present transacting, or which may at any time commence to transact, the business of life assurance in the Commonwealth, should be required to effect a registration with the Insurance Commissioner;" and No. 5 recommends "That upon the fulfilment by any company of the requirements of the Commissioner with respect to its registration, a license *to transact the business of life assurance in the Commonwealth* should issue to the company, and remain in force until such time as it is cancelled by the Commissioner." It would appear from these recommendations that the Royal Commission has arrived at the conclusion that the proposed Insurance Commissioner could authorise any company to transact business in each and every individual State. With a view to avoiding any proposed Federal legislation being based upon any apparently imperfect view of the existing legal situation, the following remarks are now offered for your consideration. It is not necessary for this purpose to consider in detail the other various proposals of the Commissioners. If the basis be incorrect, it can be adjusted at the outset, and the proposals recast before any Federal Bill is prepared for submission to the Commonwealth Parliament.

The student of Commonwealth enactments and suggested legislation cannot proceed very far without being brought up face to face with the fact that much of the suggested legislation has consisted of proposals which come only partially, if at all, within the circuit of the Federal Constitution, of which the High Court is at once the exponent and the sole guardian. Any curtailment of the sovereign powers of the individual States must be in consequence of the specific authority of the Constitution ; or else achieved by an amendment of that Constitution. The aim of some at least of our legislators has been elsewhere described as

"an attempt to transfer all powers of legislation to the Commonwealth in violation of State rights,"—with what success remains to be seen.

The Constitution Act, 1900, in relation to Trade and Commerce.—The provisions of the Constitution Act, 1900, which appear to need our present attention, consist of Section 51, which provides that the Commonwealth Parliament shall have power (subject to this Constitution) to make laws with respect to:—

(Sub Section 1).—"Trade and commerce with other countries and among the States."

(Sub Section 14).—"Insurance, other than State insurance; also State insurance extending beyond the limits of the State concerned."

(Sub Section 20).—"Foreign corporations, and trading or financial corporations formed within the limits of the Commonwealth." (*i.e.*, formed under State laws).

Now it will be evident that whether we regard insurance as possibly a branch of "trade and commerce," which is carried on by "trading or financial corporations" known as insurance companies, under State laws; or must consider it as a separate business altogether, it comes within the specific power of the Federal Parliament, although not included among those matters relative to which that Parliament has exclusive power of legislation. Insurance is not a business usually undertaken by individuals, but by corporations.

Regarding corporations in general.—We consequently need first of all to consider the peculiar nature of the unit which we term a company or corporation. It has been pointed out incidentally that "One of the marked characteristics of modern life is the creation of corporations for all kinds of business enterprises. The strength of such

institutions is so great as to constitute a very cogent reason why a strong national authority should be empowered to afford to them uniform and effective treatment." A legal definition is that "A corporation is an artificial being, invisible, intangible, and existing only in contemplation of law. Being the mere creature of law, it possesses only those properties which the charter of its creation confers upon it, either expressly or as incidental to its very existence."[1] Another legal authority says:—"The regulation of any artificial person in matters concerning only itself or the relations of its members, if any, to it, and to one another, must depend on the law from which it derives its existence. That law is its personal law, or, in other words, it is domiciled in the country of that law."[2] Now in what is known as the Union label case, the Chief Justice of the Australian High Court laid it down that "the power to legislate as to internal trade and commerce is reserved to the State by the operation of Section 107 to the exclusion of the Commonwealth"—except only as a necessary means for carrying into execution other power expressly granted. The creation of trading corporations and their investiture with needful powers and capacities is thus left entirely to the States; and the Commonwealth has nothing to do with the matter. It can hardly be contended that the Constitution has handed over to the Commonwealth, solely, the regulation of the existing body of company law. The Commonwealth cannot therefore create such a corporation; it cannot alter the conditions and nature of its existence; it cannot annihilate a corporation. What then can the Commonwealth do? It has, however, been judicially contended in various judgments delivered by individual members of the High Court (which I need not specifically quote, being more concerned with the tenor of the judgments than the

[1] Marshall, C. J., U.S.A. [2] Westlake on "Private International Law."

ipsissima verba) that it is entrusted with the regulation of the conduct of existing corporations, whether State or foreign, in their transactions with, or as affecting the public, and even respecting the conditions under which the company may trade in the State which created it; that though the Commonwealth cannot create, it can entirely forbid a foreign corporation doing business in Australia except on such conditions as it prescribes—that it can, for instance, prescribe conditions as to paid-up capital, as to securities to be deposited, and as to the official reports and returns to be made to Government; all of which functions have hitherto come under what may be called the existing "police provisions" of the current State Acts regarding companies. The field of domestic trade, which was reserved to the States, is in effect, claimed as having been transferred to the Commonwealth. On the other hand it has been also judicially contended that sovereign States alone can create corporations; and it should follow accordingly that the States hold the dominant position in regard to such legislation. Where the Federal authority invades the sphere of State legislation, and steps outside the ambit of the Commonwealth powers—then, to quote a judicial allusion, "although a dog can wag the tail, it by no means follows that the tail can wag the dog."

It will perhaps help in the consideration of this important point if we consider what has been already decided by the High Court. The full Court (in Huddart Parker & Co. *v.* Moorehead), held that Section 51 (20) "does not confer on the Commonwealth Parliament power to create corporations, but the power is limited to legislation as to foreign corporations and trading and financial corporations created by State law." We may notice that such corporations do not include all kinds of corporations; they include insurance companies, but not manufacturing companies, mining com-

panies, and probably not a drapery company formed in a single State and confining its business to that State. We may also notice incidentally that whilst banking is included in sub-section 13 of section 51, power is explicitly given to the Commonwealth regarding the incorporation of banks, so that apparently the Commonwealth can incorporate (*i.e.*, create) a bank, though it cannot create a financial corporation. Obviously where there is authority to incorporate, there is implied power to impose conditions contingent upon and prior to the grant of such incorporation. It has been said that sub-section 20 of section 51 was intended simply to place upon one level corporations which have been created by either State law or the law of a foreign country; and consequently that the difficulty, if any, lies in fixing the respective limits of the powers of the Federal and State Parliaments. For instance, assuming that the State may make a law concerning some trade, which either individuals or companies may carry on, could the Commonwealth pass such a law as to govern a company without governing the individual also? Suppose, to take another illustration which has been used, that the Federal Parliament decides to confer upon corporations the power to hold lands as a matter of corporate capacity; whereas the State legislature, having control of its own lands, forbids a corporation when admitted by it as a legal entity from holding land—is the Commonwealth law to prevail? It has been decided that the Constitution must be construed as a whole, and where either a wide or a restricted meaning can be given to some particular provision therein, then that meaning is to be adopted, "which best gives effect to the distribution of the powers between the States and the Commonwealth." The Commonwealth has probably no power over contracts within a State; the State law governs such, whilst the Commonwealth power to make any laws is subject to the Constitution itself.

Now a corporation is a local domestic creation under some State law, with strictly prescribed functions, powers and liabilities; and therefore not entitled to privileges accruing to ordinary individuals composing the population of the country; and because such are artificial persons created by the legislature, and possessing only those attributes which the legislature has prescribed, "they can have no legal existence beyond the limits of the sovereign State where created. The recognition of existence of a corporation, even by other States, and the enforcement of its contracts made therein, depend purely upon the comity of those States."[1] The Commonwealth (whatever its powers may be) cannot compel a State to admit a company satisfactorily operating under Commonwealth power (if this be even possible) except on terms equally satisfactory to that State. If the State has no power of internal restriction, then "the principal business of every State would, in fact, be controlled by corporations created either by other States," or by foreign companies acting under Commonwealth authority, to the possible detriment of the residents of such State, as has been pointed out in decided cases in the United States. The State has always an inalienable police right of protecting its own people, for instance, against dishonest practices on the part of either individuals or corporations operating within its borders; the Commonwealth cannot interfere with,—whatever may be its power to aid in,—the efficient discharge of these police duties. In the High Court decision in the "Woodworkers' case,"[2] the Chief Justice held that the part of the Constitution governing the matter before the Court "is to be construed having regard to the rest of the Constitution, and particularly with regard to the doctrine repeatedly laid down by this Court,

[1] Field, J., in Paul v Virginia, 1868, U.S.A.

[2] 8 C.L.R., 465 at p. 495.

that any invasion by the Commonwealth of the sphere of the domestic concerns of the States appertaining to trade and commerce is forbidden, except so far as the invasion is authorised by some power conferred in express terms, or by necessary implication." He held also in the "Boot Trade Employees' case,"[1] that "The Commonwealth had admittedly no power to interfere directly with the domestic industry or police power of a State."

We come then to the point arising that when a State law is inconsistent with Commonwealth law, the latter shall prevail, and the former to the extent of the inconsistency is invalid (vide Sec. 109 of the Constitution Act). The test of such inconsistency has been stated to be whether a proposed action was inconsistent with obedience to the mandates of *both* Federal and State authority. These mandates may differ in terms, but so long as they are not contradictory of each other, they may need both to be obeyed. Now, in the "Harvester case"[2] it was decided by the High Court that "the power to impose taxation must be considered with reference to the powers reserved to the States." Yet the minority of the Court then held that the power to tax was of the widest, and urged that "the unlimited character of Federal power, once it attaches to a subject, is strikingly exemplified in the most recent of the great constitutional decisions of the American Supreme Court." It was further pointed out that "legislation in a great variety of ways, may affect commerce and persons engaged in it, without constituting a regulation of it within the meaning of the Constitution. . . . . . If the defendant is right, there lies before us the prospect—agreeable perhaps to a limited class, of perpetual struggles, in which attempts will be made to treat State laws as invalid because they affect (incidentally,

[1] Australian Boot Trade Employees' Federation *v* Whybrow and others.

[2] *Re* Excise Tariff Act, 1906, regulating internal trade and industry.

as in this case) Federal subjects, and Federal laws as invalid because they affect similarly State subjects; and the State Governments will find that the doctrine will react with baneful pressure on their own activities." It seems almost grotesque to find that the State Governments are to apprehend evil as the result of a legal decision of the majority of the High Court, directed towards conserving the sovereign rights of the States. The Federal Legislature seems to have aimed in certain instances at gaining control over the States in as many ways as possible; and although the same population constitutes both the Commonwealth and the States, yet it is self-evident that there may be differences in the internal interests of a State as compared with those of its immediate neighbours. Take the mining industry, for instance: in each State there are mineral deposits, there are consequently mines; and the mines are being developed by domestic corporations under State laws. Is it practicable, or ever intended, to place all such companies in all their details of working and control under the aegis of the Commonwealth Government, to the ignoring of the State authority and the interests of its people? To state the case seems to carry with it a refutation of the idea. The Commonwealth can with advantage perhaps enact some provisions of a broad nature which should govern corporations in all the States: but beyond this, each State will probably prefer to control the operations of its own companies, and to enact such special local provisions as may be deemed advisable.

Regarding Life Insurance.—Now, from a consideration of these general observations we may turn more especially to the smaller issue, necessarily covering to some extent the ground already traversed in connection with the operations of companies in general, concerning the business of insurance companies in relation to the provisions of Sec. 51

of the Constitution Act, already quoted. Since insurance is a subject which, as we have seen, is specifically brought under the power (but not exclusive power) of the Federal Parliament, the operations of insurance companies formed within the limits of the Commonwealth, although not created by the Commonwealth, may be the subject of both Federal and State legislation. As regards fire and marine insurance also (and probably the kindred business of banking) the position under the Commonwealth and the State laws is an identical one. Be it remembered also that the companies in doing business are selling insurance policies, "which are not commodities to be shipped or forwarded from one State to another and then put up for sale. They are like other personal contracts; they are local transactions and governed by local law."[1] In a paper read by me nearly four years ago, on 27th August, 1906,[2] I expressed an opinion which I may perhaps be pardoned for repeating now:—"Any State Government may continue to make internal laws not only regulating insurance companies but imposing taxation within the borders of the State, and so long as such State laws, however embarrassing to the offices, can be read as ancillary or complementary to, the concurrent Commonwealth law, it will be necessary for the offices to submit to both laws, notwithstanding that the internal laws of one State may be quite in opposition to the laws of another State in the same matter. The only way of securing uniformity may be for the Commonwealth Parliament to pass that which for a considerable time past it has been its expressed intention to enact—a strictly Federal measure regulating the business of insurance, and thus (for the time being at all events) to give the desired initial uniformity to legislation, *subject however, to express*

[1] Field, J., in Paul *v.* Virginia.

[2] Before the Actuarial Society of New South Wales, *vide* "The Review," Sydney, 1906, p. 432.

abrogation by the States of their existing local laws in so far as these do not become *ipso facto* invalid by the passage of the principal Federal enactment itself. Of course, the various State legislatures may at any time subsequently deem it necessary to re-enact such supplementary provisions as they may consider essential."

It may perhaps be deemed necessary hereafter for the Federal authorities to enter into a conference with the State Governments, including New Zealand, and then endeavour to arrive at some satisfactory arrangement as to the practicable limits of their respective spheres of legislation. That the Royal Commission has not made such a proposal is I think matter for regret. What needs to be aimed at is that the Federal and State powers should be so carefully balanced that either the one or the other can be relied upon to prove efficacious and energetic in putting down evil-doing—for it is a necessary measure of restriction which should be aimed at by any proposed legislation. As the Royal Commission[1] have put it:—"The assurance and annuity funds of the companies transacting life assurance and annuity business are essentially trust funds, and should in the interests of the public be subject to a certain measure of legislative control," and few will be found to combat entirely this averment. It has been said by someone that really "there is no twilight zone between the nation and the State." There ought not to be any, but judging by American experience under conditions somewhat resembling our own, we may conclude that "State rights and Federal rights have been played off against one another by people whose only desire was to evade effective control by either." An important illustration is afforded by the Canadian case of King *v.* Willis, Faber & Co., in which Mr. Justice Leet, of the Province of Quebec, decided only a few months ago

[1] Recommendation No. 3. 1910.

that the regulation of insurance is not contemplated by the British North America Act establishing the Dominion, which decision it is said "has thrown things into chaos in the Dominion, so far as the assertion or exercise of authority on the part of the Dominion over insurance matters throughout all the provinces is concerned."

Regarding American and Canadian Legal Decisions.—Now, in the United States the several States are independent of the Federal Government in legislation, although State legislation may be set aside by the Courts if held to be untenable. In Australia, State rights are the keystone of the Federal scheme, thus following the example in certain limited respects of the United States. In Canada the Federal Government has the right of vetoing Provincial legislation. In that Dominion the practice has grown up of insurance companies taking out Dominion charters, which practice has the effect of bringing the companies directly under the supervision of the Dominion, since its Parliament can obviously claim to regulate the institutions which it has itself created and chartered. But as has been well pointed out, "The precise effect of a Dominion charter has perhaps not yet been adjudicated, especially with regard to whether or not it gives the right to do business throughout Canada, even against the provisions of the laws of a particular province. It has scarcely been an open question from the very beginning that a particular province may charter its own companies and permit them to do business without regard to Dominion statutes; nor even that a province may permit a company from another province or even from another country to do business, even though the same be not licensed under the Dominion regulations."[1]

Mr. Justice Leet in the case just referred to, held that the subject is relegated to the provinces, which alone have

[1] *Vide* "The Chronicle," New York, 3rd March, 1910.

the necessary authority to decide whether a company can do business in a province or country when the company has not been licensed by the Dominion. The Minister of Justice (Hon. A. B. Aylesworth) speaking in the Dominion Parliament at Ottawa quite recently, stated that the case was "but one phase of a larger question as to the powers respectively of the Dominion Parliament and of the local Legislatures in regard to the incorporation of companies. That question was not long since raised for the decision of the Supreme Court, and the members of that Court differed among themselves very decidedly in the opinions they expressed." He also stated that a meeting was proposed between representatives of the provinces and of the Dominion Government to discuss the whole subject; "not merely the question of the insurance legislation but the larger one as to the right to incorporate companies in the provinces and in the Dominion respectively." Now, if the matters to which reference is thus made are in doubt in Canada, is it improbable that they are involved in doubt in Australia also? In the United States a Corporation Tax law has for the first time just been passed; and the various life companies have promptly applied to the Supreme Court at Washington for relief from the new taxation so far as it affects their interests. The offices claim that "Individuals and ordinary partnerships engaged in similar businesses are not taxed. How can a tax on A and B and not on C and D, when all are carrying on the same kind of business, be a tax on business or occupation? The tax, as a franchise tax, constitutes so far as State corporations are concerned an interference with the sovereign powers and functions of the States, not surrendered to the general Government and expressly reserved to the States by the tenth amendment to the Constitution."[1] The result of this litigation will be looked for with interest.

[1] *Vide* "Spectator," New York, 24th March, 1910.

Regarding the Life Assurance Foreign Companies Bill 1906, (withdrawn).—With regard to insurance offices it should be remembered that in Australia in September, 1906, a Life Assurance Foreign Companies Bill was introduced into the House of Representatives, some of its provisions being similar in scope to some of the proposals of the recent Royal Commission; it was, however, properly characterised as "harsh and crude," and eventually it was not proceeded with. This result is to some extent instructive, since it may be assumed that the proposals which were then made were found on consideration either to be untenable or unnecessary. Probably fuller consideration showed that in relation to life insurance, the power of the Commonwealth was ascertained to be less extensive than perhaps at first sight was assumed; just in the same way that certain difficulties in regard to proposed land taxation by the Commonwealth have yet to be faced. As one authority has said:—"The Federal Parliament may have power, according to the letter of the law, to tax land in order to raise revenue, but no one can say that the Constitution takes from the States an atom of their right to say how land shall be held under the Crown, or names land as one of the subjects transferred to the Federal Parliament." If, instead of land, we may substitute insurance, we shall have an idea of what is possibly a kindred serious difficulty regarding the actual present legal position of the life offices of Australia.

THE VOLCANIC NECKS OF HORNSBY AND DUNDAS NEAR SYDNEY.

By W. N. BENSON, B.Sc.

[With Plate XXXIV.]

[*Read before the Royal Society of N. S. Wales, November 2, 1910.*]

Part I. Geneal.

Introduction.—The volcanic necks at Hornsby and Dundas have been known to geologists for a considerable time, and the latter has been frequently mentioned in literature. The earliest record of Dundas is that by J. D. Dana.[1] It is also mentioned by the Rev. W. B. Clarke[2] and was reported upon by C. S. Wilkinson.[3] The last named recorded the occurrence of numerous inclusions of foreign rock in the

[1] Report of U. S. Exploring Expedition, 1838-42, Vol. x.
[2] Transmutation of Rocks in Australasia. Trans. Phil. Soc. N.S.Wales 1862-1865, p. 292,
[3] Ann. Rep. Department of Mines, N.S.W., 1876.

basalt. The most detailed account is that given by Prof. David, W. F. Smeeth, and J. A. Watt.[1] They described the included boulders of basic plutonic rock as rounded by the corrosion of the molten basalt, and noted the presence of chromite, of chrome diallage, of a green mineral formed by decomposition of chrome diallage, and mentioned the occurrence of a rock composed of chromite and anorthite—a chromite-anorthosite. Some doubt was thrown on the last determination by the Rev. J. Milne Curran.[2] Mr. G. W. Card,[3] Dr. H. I. Jensen,[4] and Mr. C. A. Süssmilch[5] have drawn attention to the widespread occurrence of blocks of plutonic basic rock as xenoliths in intrusions of various types of rocks, more especially basalts. Messrs. Taylor and Mawson note that at Dundas they are sometimes more acid than the basalt including them.[6] Mr. Card has described the basalt of Dundas, which was analysed by Mr. H. P. White.[7] The neck at Hornsby was noted and mapped by the Rev. J. M. Curran and Mr. C. A. Süssmilch, and described by Mr. M. Morrison.[8] Nevertheless no very detailed account of the petrology of these interesting localities has yet been published. The following is a contribution towards such a study.

Field Geology.—*Hornsby.*—The volcanic neck of Hornsby is an area about a mile and a quarter long, "the Old Man Valley," lying to the west of the railway station. A geological and topographical map of the neighbourhood is given below. A careful examination of all the exposures

[1] Proc. Roy, Soc. N.S.W.. 1893, p. 401.
[2] Geology of Sydney and Blue Mountains, p. 262 footnote.
[3] An Eclogite Breccia from the Bingera Diamond Fields, Rec. Geol. Survey, N.S,W., 1902, Vol. VII, Pt. ii, p. 39.
[4] Proc. Linn. Soc. N.S.W., Vol. XXXII, 1907, p. 907.
[5] Proc. Roy. Soc. N.S.W., Vol. XXXIX, 1905, p. 65.
[6] Proc. Roy. Soc. N.S.W., XXXVII, 1903, p. 349.
[7] Notes on Analyses of Olivine basalt from the Sydney district. Rec. Geol, Surv. N.S.W., 1903, Vol. VII, Pt. iii, p 229.
[8] Rec. Geol. Surv. N.S.W., Vol. VII, Pt. iv, p. 21.

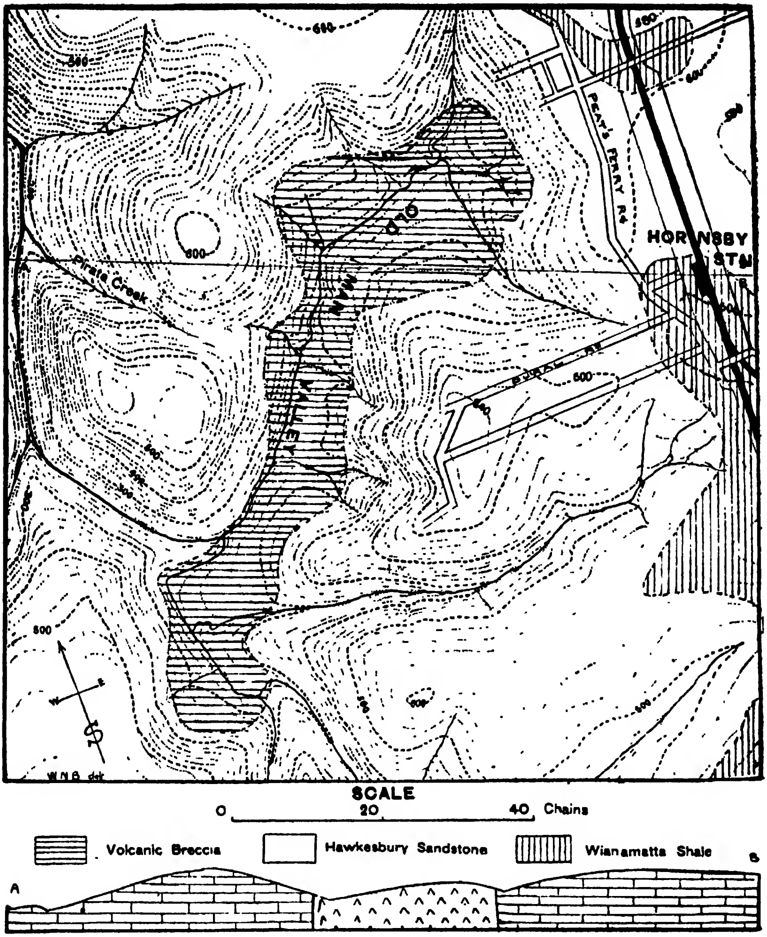

Fig. 1—Topographical and Geological map of the Hornsby volcanic vent and its immediate neighbourhood, with section.

of volcanic rock adds little to the information given by Mr. Morrison. Briefly, the neck is composed of a grey basic volcanic breccia which breaks through Hawkesbury sandstone, that on the eastern side, is dipping at an angle of about two degrees towards the south-east. This sand-

stone is capped by Wianamatta shale lying on an eroded surface. This may be well seen in the first railway cutting north of Hornsby station.

The soft nature of the breccia has allowed comparatively rapid erosion, and the neck is shown physiographically by a trench three hundred feet deep in the peneplain level, which extends the whole length and breadth of the volcanic area. It runs in a south-westerly direction, and is drained into Tunk's Creek to the north by a narrow gorge from near its southern end. It receives the drainage of deep narrow gullies from the north, east, and south. The last gully has a curious course, it flows north towards the outlet, then bends sharply to the east and then joins the main creek, flowing west into the outlet, thus leaving a narrow tongue separating the two creeks. This is possibly due to a local hardening of the sandstone, the effect of the volcanic intrusion. Of interest also is an example of incipient domestic piracy; Pirate Creek will soon capture the northern portion of the Old Man Valley drainage system.

The volcanic rock filling the neck is a breccia, the inclusions of which will be described below. Briefly it consists of grey kaolin, carbonated, and chloritic material, with quartz grains and pebbles, fragments of sandstone, plentiful inclusions of a peculiar trachytic basalt in various stages of decomposition, occasionally small patches of bitumen, many calcite veins, and very rarely small fragments of essexite, peridotite and serpentine. The best exposures are in a small quarry on a tributary creek in the centre of the neck, and at another small quarry in the bend of the main creek to the north-west of the cultivated area. After careful search along every water course, no sign could be found of any intrusion of basalt into the breccia. The soil of the volcanic area is good; it is cultivated in the northern and southern portions of the neck, and where uncultivated

the boundaries of the volcanic area can be determined by a line limiting the occurrence of *Eucalyptus saligna*,[1] the commonest tree on the basic rock.

Dundas.—The volcanic neck of Dundas is of much smaller size than that of Hornsby but far more complex. It was originally a hillock of columnar basalt outcropping through Wianamatta shale;[2] but it has been quarried intermittently for the past eighty years, and is now exposed in a quarry about a hundred and sixty yards long, a hundred yards wide, and over a hundred feet deep. (See Fig. 2) Good

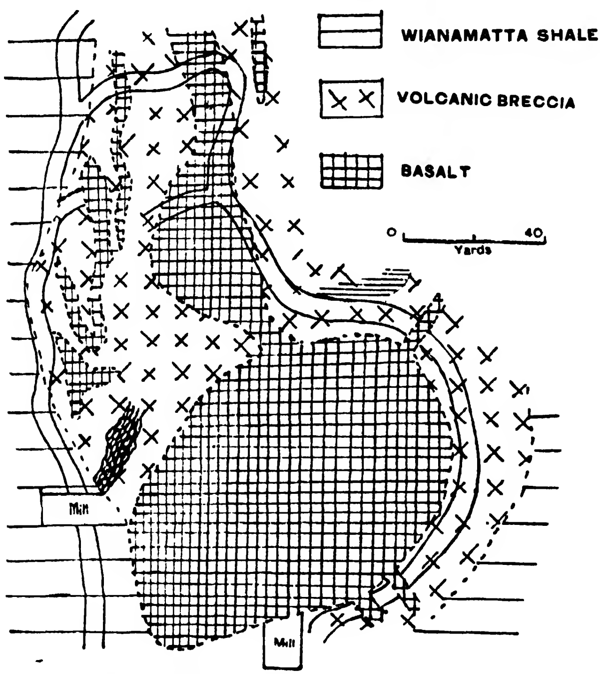

Fig. 2.—Geological sketch-map of the Dundas volcanic neck.

sections are thus exposed, which, however, cannot be traced beyond the excavation, the cultivation of the soil obscuring

[1] Kindly determined by Mr. R. H. Çambage.

[2] W. B. Clarke, *loc. cit. supra.*

all outcrops. Wianamatta shales are exposed on the western and southern side, often considerably hardened by baking. The eastern and northern surfaces are mainly of very much decomposed breccia. This is composed of fragments of Hawkesbury sandstone (which underlies the Wianamatta shale at no great depth) and fragments of Narrabeen conglomerate. I have found here a green conglomerate with pebbles of jasper similar to that occurring at a depth of 2,400 feet in the Balmain Colliery shaft, in the jasper of which Mr. R. S. Bonney has found casts of *Radiolaria.*

Blocks of basalt also are plentiful in the breccia, and fragments of the plutonic rocks to be described later, generally in a highly altered condition. The central portion of the neck is filled in with a green breccia, perhaps the unweathered equivalent of that previously described, but more clearly of the same character as the breccia filling the Hornsby neck. At the sharp bend in the old cart track on the eastern side is a mass of grey current bedded sandstone covered by carbonaceous shales. These appear to have been brought up from the coal measures. They are broken through by a mass of breccia to the east. On the western face they appear as irregular black patches dotted with white rock, and dipping at a high angle. This is the broken up and brecciated equivalent of the horizontally placed carbonaceous beds on the opposite side. The main mass of the basalt breaks through the breccia and forms an oval area some eighty yards long and fifty wide. It has sent many veins into the surrounding rocks as shown in the sketch map; in particular the breccia is seamed with irregularly running veins, (shown diagrammatically only) and in places seems to have been broken up and recemented by a paste of basalt. The largest basalt vein in the centre of the quarry shows excellent semi-radially arranged

basaltic columns. In this basalt the plutonic inclusions have been well preserved. They form large or small pebbles, rounded, as suggested by Professor David, by magmatic corrosion, and comprise a long series of rocks. They include anorthosites, gabbros, hypersthene gabbros, olivine gabbros, norites, lherzolites, harzburgites, dunites with gabbro-porphyries and olivine dolerite. These present many remarkable and unusual features in their manner of alteration, which will be described in some detail.

The cracks and minor fault planes in the basalt and breccia are filled with chlorite, quartz, calcite or siderite, while well crystallised calcite aragonite barytes and amethystine quartz may be found in small vughs. Pyrites also occurs in irregular grains and well formed crystals.

Part II. Petrological.

In describing the petrological features of these rocks it seems best to first consider the mode of occurrence of the minerals of the plutonic inclusions of Dundas and their alterations, following this by an account of their association into various types of rock and their structural and chemical characteristics and relationships. This will be concluded by a description of the other types of rocks studied.

Minerals of the Plutonic Inclusions.

Felspar.—The only felspars present are plagioclase, sometimes this is labradorite, but often it is bytownite, as shown by the extinction angles, and the refractive indices determined in flakes by the method of Shroeder van der Kolk. It occurs in fairly large grains, almost completely allotriomorphic. Albite twinning is usually shown by broad or narrow bands sometimes crossed by pericline lamellae, which sometimes appear best developed at points of strain.[1]

[1] Judd, Quart. Journ. Geol. Soc. 1885, p. 365. W. G. Woolnough, Proc. Roy. Soc., South Australia.

Where the felspar has been strained and the lamellae bent, thin lenticular concave-convex lamellae, twinned on the albite law appear between the long bent lamellae. (See fig. 3.)

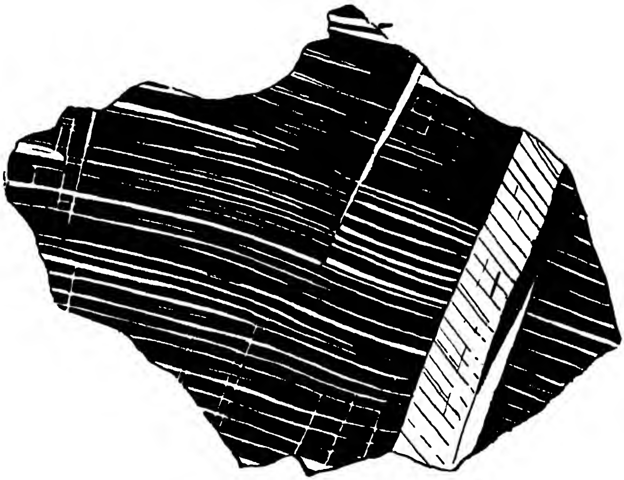

Fig. 2.—Additional twin lamellae developed in plagioclase at points of strain.

Alterations.—In his work on the gabbro rocks of Scotland Judd[1] has described in detail the processes of alteration which felspars may undergo under fairly deep seated conditions, the processes being akin to schillerization, and resulting in the production of chatoyant forms of felspar. Effects precisely similar to those observed by Judd are exhibited by the felspars of the Dundas rocks. In these have been developed long cavities, negative crystals, lying chiefly parallel to 010 but also in several other planes. These are filled in with dark oxides, magnetite, ilmenite, chromite or rutile. Lacroix[2] opposed Judd's view, and his alternative hypothesis has recently received the support of

[1] J. W. Judd, *op. cit.*, pp. 375 and 386.

[2] Bull. Min. Soc. France, April, 1889.

Vogt,[1] who considers the felspar crystals to have been originally supersaturated in these dark coloured oxides, which have since crystallised out from the solid felspar. Still it must be noted that it is only in the more altered of the Dundas rocks, where, from other evidence, there is most sign of the percolation of solutions that these small secondary plates or cavities have formed, for occasionally they appear to be cavities not filled by oxides.

A second alteration, more plainly in accord with Judd's views is not confined to felspars only, but is common to the rock as a whole. Bands of very minute irregularly shaped cavities either filled with liquid or with oxides, pass in a serpentinous manner through the rock from mineral to mineral (see fig. 4). When these cavities are filled with

Fig. 3—Band of cavities filled with liquid in felspar, highly magnified.

black oxides they recall Harker's typical figure of a dendritic separation of material with which the host (there olivine)[2] had been supersaturated. They are in Dundas, however, generally in droplets, not in such complex dendritic forms. Felspar, pyroxene, olivine, and even spinel occasionally may contain these cavities.

A third common mode of alteration is the deposition, in cleavage cracks and other partings, and in intergranular spaces, of a dull green mineral of rather high birefringence

[1] Quart. Journ. Geol. Soc. 1909; see also Harker, Natural History of Igneous Rocks, p. 257.

[2] Natural History of Igneous Rocks, p. 258.

and refractive index. At other times the refractive index may be lower; this is probably secondary mica and chlorite. Sometimes small crystals of calcite and brightly refracting colourless plates (talc ?) may also be present. Felspar thus altered has a dull green appearance. As a general rule calcite, kaolin, and epidote do not form as decomposition products of felspar.

Monoclinic Pyroxenes.—Diallage, augite, diopside, hypersthene and enstatite are developed in different types of plutonic inclusions. In any study of a series of gabbroid rocks the question of the status of diallage always arises, whether it should be considered a species, or as an alteration form of augite and diopside.[1] Judd[2] considers it to be a variety only, produced by schillerisation in much the same manner as the production of chatoyant plagioclase. Zirkel considers its leafy nature a sufficient index of specific character. The position has been briefly summarised by Henderson.[3] More recently Harker has stated his disbelief in the secondary origin of the schiller plates.[4] The Dundas rocks show that in those types which are most altered, and in which the felspar is richest in platy inclusions, the platy inclusions and leafy nature of the diallage are best developed; in rocks less altered, we have merely the schiller inclusions developed in varying degree, and with them a trace of the parting parallel to 010. In the diopsides of the peridotites this is sometimes only very faintly developed, if at all. Thus the gradual transition of augite and diopside into a diallagic form does not seem improbable. It is, however, in those forms, in which, though there is a marked development of schiller plates, there is little or no sign of lamination that Vogt's explanation seems most probable.

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1 See literature cited by Teall, British Petrography.
2 Quart. Journ. Geol. Soc., 1884, pp. 378 and 386.
3 On Certain Transvaal Norites, Gabbros and Pyroxenites, 1898.
4 Tertiary Igneous Rocks of Skye, 1904, p. 109.

The diallage has been studied in some detail, a large crystal in the gabbro-porphyry affording good material. It was brown in colour and of a silky lustre. Partial chemical analyses showed the presence of ·33 per cent. of chromium sesquioxide and ·14 per cent. of oxides of nickel and cobalt though the lower figures obtained in the analyses of the diallagite (·24 and a trace respectively) show that the diallage cannot be considered of constant composition in regard to these minor constituents. This quantitative work confirms the previous determination, by borax bead only, of the presence of chromium in the diallage.[1] By Shroeder van der Kolk's method the refractive index β was determined in red light to be 1·679. The position of the acute bisectrix was given by $\mathfrak{c} \wedge c = 36°$. On a cleavage flake the angle between one of the emergent optic axes and the c axis was determined, and using the above figures the optic axial angle was calculated to be 59° 40′ in red light. This result is, of course, no more than a rough approximation. The dispersion of the optic axes is slight, ρ is greater than ν. By grinding oriented sections of diallage with plates of quartz cut parallel to their optic axis, and comparing their birefringence with a Babinet compensator, the double refraction on (100) was shown to be ·004 and that on (010) which is the maximum birefringence $(\gamma - \alpha)$ was ·023. In other samples of diallage the extinction angle $c \wedge \mathfrak{c}$ rose sometimes to 39°.

Thin strips may be seen in section to run parallel to (100) with an orientation different from that of the rest of the crystal. It was not clear whether these were interpositions of hypersthene or twin lamellae of diallage, but owing to the high birefringence and oblique extinction of some of the lamellae, the latter is considered the more

[1] Professor David, Smeeth, and Watt, Proc. Roy. Soc. N.S.W. 1893, p. 401.

probable. Some lamellae however have nearly straight extinction. In some slides, undubitable multiple twinning of diallage is present, and in others single twinning of the augite appears to occur though it is not quite definite. Occasionally the diallage is noticably pleochroic, the colours varying between a pinkish and a greenish-brown.

In the augites sometimes schiller inclusions are present parallel to 100, giving a slightly diallagic appearance, especially when viewed in a direction parallel to the vertical axis. In the augites the extinction angle $\mathfrak{c} \wedge c$ rises to 54°. In the colourless pyroxene, that occurs in the ultrabasic rocks, the extinction angle is between 40° and 41°. This diopside has sometimes a slightly developed diallagic parting parallel to (100).

Rhombic Pyroxenes.—Both hypersthene and enstatite occur, the former in the more acid gabbros, the latter in the peridotites. Hypersthene forms roughly rectangular grains when cut parallel to the basal plane; in other positions it is more irregular in outline. It is often strikingly pleochroic in tints of pale green and pink to purplish-pink. Enstatite occurs in the peridotites in colourless rounded grains.

Alterations.—The alterations of the diallage are varied. The origin of schillerisation cannot as yet be definitely referred to as a secondary process; its effect having already been discussed, it will not be further considered here. The formation of long bands of irregular cavities has been already described; they are particularly common, forming along the boundaries of the pyroxene, the planes separating the grains from adjacent grains being an easy passage for solutions. The cavities are generally filled with opaque oxides. It is in the transformations of the pyroxene that the greatest difficulty arises in the study of these rocks. Diallage changes into an aggregate of matted flaky or

fibrous green or brown substance, with a strong double refraction and moderate refractive index. The pleochroism varies with the depth of colour, the tints being from yellowish-brown to pure green, the absorption being in the darker flakes almost total parallel to the cleavage. This Mr. J. A. Thomson considers to be biotite, and it is this biotite apparently which is introduced by solutions into the cleavage planes of the adjacent felspars. This alteration to mica is quite different to that developed by interaction of pyroxene and felspar as described by Parsons.[1] In addition to the biotite there may be developed confused brown aggregates of chlorite, or pale green pleochroic spherulites or irregular flakes of the same mineral, the double refraction of which is only slightly higher than that of the plagioclase. With this is often associated grains of carbonates, calcite, magnesite, siderite or combinations of these. Possibly also a little actinolite is formed but its presence could not be definitely proved.

The rhombic pyroxenes have two main methods of alteration. In the majority of cases they pass into actinolite, the alteration taking place at the boundaries and along transverse cracks; the fibres lie parallel to the cleavages of the pyroxene (see fig. 5). This, however, is best developed

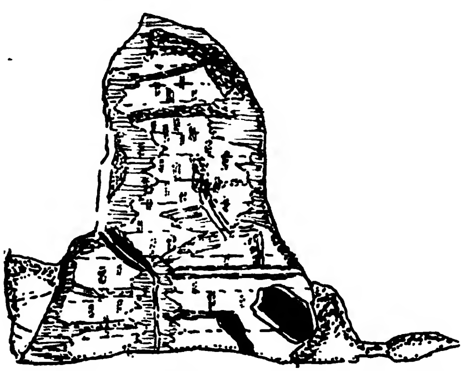

Fig. 5.—Hypersthene, showing schiller plates and formation of fibres parallel to the cleavage.

[1] Geol. Mag., 1900, p. 319.

in the hypersthenes of the gabbros. The enstatites of the peridotites usually remain unattacked while the surrounding olivine is completely altered. In one rock, however, enstatite was observed to pass into a fibrous brown pleochroic mineral of high birefringence and straight extinction. This is probably anthophyllite. In the same slide the diopside was unaltered.

Olivine forms ovoid grains with little or no approach to idiomorphism. Its cleavage is sometimes fairly well developed. It is quite colourless under the microscope. It seems to be free from the schiller-like dendriform inclusions of magnetite described by Judd[1] and Harker.[2]

Alterations.—Olivine has far more varied forms of alteration than any other mineral in the Dundas rocks, and crystals of olivine in close continuity to each other may be altered in completely different ways. Like the other minerals of these rocks, its first method of alteration is to become crossed by bands containing irregular depositions of opaque oxides not of dendritic form. These bands form most readily in the cracks of the olivine, the easiest passage for solutions, though they are by no means confined to these cracks. The normal alteration to serpentine, pale yellow, grey-blue, or colourless takes place also, the fibres developing normally to the cracks and when fully developed giving a serpentine rock with the ordinary mesh structure.

A third alteration is to calcite, siderite, and magnesite, occurring in dusty cloud-like bands often crossing the grains in arcuate lines, or in series of V-shaped angles, or forming in massive crystals. Carbonates also occur occupying the centre of a mesh in the serpentines.

A fourth, and the most common type of alteration, is to greenish silicates. Several minerals are to be found among

[1] Quart. Journ. Geol. Soc., 1885, plate xii, fig. 1.
[2] Tertiary Igneous Rocks of Skye, p. 109.

these. In some cases the olivine is replaced by a confused aggregate of green pleochroic fibres with slightly oblique extinction, which are probably actinolite. Crystals so altered resemble the "pilite" pseudomorphs after olivine in lamprophyres. In other cases the mineral is of faint pleochroism, but the extinction is straight. The birefringence is strong and a is parallel to the length of the fibres. This mineral seems most probably anthophyllite. The central portion of the grain may be filled in with finely matted and less highly coloured anthophyllite or it may be pale green pleochroic platy substance like the biotite of the diallage, though not so highly coloured. Again the central portion of the grain may be of talc in colourless or very pale green flakes or fibres of high birefringence, occurring in rectilinearly bounded sectors, which seem to have no definite orientation. The fibres of neighbouring sectors interlace with mutual compensation. Occasionally there is a distinct sign of multiple twinning in the talc plates. In dunites this alteration takes place along bands of easy passage for solution. The lateral portions of these show pale to medium green actinolite and anthophyllite, the central portions very pale talc. The intergranular partings are marked by dusty carbonates. The bands of black oxides deposited in irregular cavities are partly or completely resorbed during this type of alteration.

Another type of alteration has several varieties. Quartz is present in varying amount and manner. There are actinolite-quartz pseudomorphs after olivine in which the quartz forms small irregular, often interlocked grains, either scattered through the pilitic material or forming a central area rimmed round and crossed by bands of pilite, (fibrous amphibole). Sometimes the quartz forms a plate occupying the whole area between the actinolite bands; in other instances it may be in interlacing groups of parallel

plates, apparently replacing talc or serpentine. In one instance, quartz, talc, and serpentine occur together with much finely divided carbonate filling the original cracks. In another rock quartz and carbonates alone represent the olivine, the carbonates being in the cracks or arranged in bands sometimes bent in a parallel series of lines, the quartz being arranged in lines parallel with these. The whole seems to be pseudomorphous after talc or serpentine, at other times the carbonates may be more irregularly distributed, the quartz in larger plates or in small irregularly placed plates. Some areas again appear to be strictly pseudomorphous quartz with very small amounts of carbonate or silicate. (See *Plate 34*, fig. 1.) Carbonates may predominate in other areas, and a false appearance of plagioclase twinning is given by the presence of clear roughly parallel veinlets of quartz in the carbonates. In one rock opal occurs in the central portion of a serpentine mesh. Finally we have the complete replacement of the olivine by carbonates without any trace of structure preserved. The alteration of olivine to chlorite also appears to occur; in one instance the birefringence of the green material being too low for biotite, and the pleochroism too weak. The chlorite is in simple subradiating groups.

Ilmenite occurs as grains with an irregular rounded outline, sometimes slightly idiomorphic. It is generally decomposing into leucoxene, either peripherally or in a regular tri-linear network. In these rocks the ilmenite is invariably surrounded by, or associated with, a mass of chlorite of a very pale apple-green colour, and which is composed of fibres grouped in subradiate areas or tufts of low birefringence. In this are irregular grains, or sometimes vermicularly shaped patches of a carbonate, and rarely small flakes of biotite.

Pyrites occurs in certain of the rocks in idiomorphic crystals or irregularly shaped grains. It is, however,

invariably secondary. It occurs always in cracks which would form solution passages and nearly always is in association with calcite.

Spinels.—Pleonaste is present in many of the rocks. It is bluish-green in colour and without cleavage. It is, however, crossed by large cracks, in which in the more altered rocks, opaque oxides may be deposited. In most instances it forms rounded or irregularly bounded grains, but in many cases it forms a granophyric intergrowth with the pyroxene. This will be described in more detail later.

Picotite occurs in the ultrabasic rocks. It forms dark brown to lighter brown-green rounded grains, without cleavage, but with cracks often containing black oxides. There is no sign of its forming graphic intergrowths with the pyroxene. Professor David and Messrs. Watt and Smeeth[1] reported the presence of chromite at Dundas. While this may occur, in the two ultrabasic rocks I have analysed, the spinel is clearly picotite as shown by the high percentage of alumina. It therefore seems probable that the majority, if not all, of the brown spinel is picotite. According to Rosenbusch, chromite is indistinguishable from picotite except by a chemical analysis which was not made by the authors cited.

Apatite has not been noted.

Carbonates, calcite, siderite, and magnesite occur in irregular grains, rarely with any crystal outline; also in very fine dustlike particles in the intergranular planes and in cracks.

Rocks of the Plutonic Inclusions.

The mineralogical composition of the rocks may be shown in the following manner. Basic and ultrabasic plutonic rocks of the normal type, composed essentially of relatively

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[1] Proc. Roy. Soc., 1893, p. 401.

varying amounts of plagioclase felspar, rhombic or monoclinic pyroxene, or both, and olivine may be classified by their position in the following diagram. (Fig. 6.)

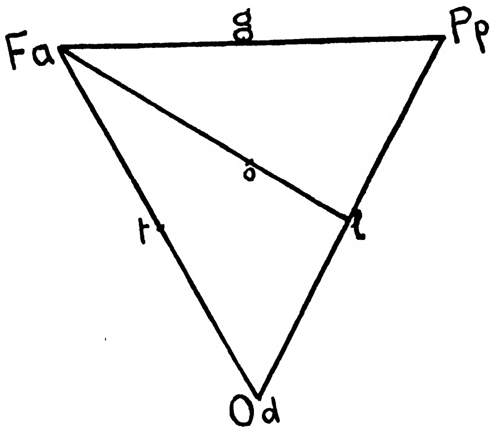


Fig. 6.—Variation diagram of basic and ultrabasic plutonic rocks.

F. P. O.—Felspar, pyroxene, olivine.
a.—Anorthosite. *g.*—gabbro and norite.
p.—Pyroxenite (diallagite, websterite, enstatolite).
l.—Lherzolite, wehrlite, hartzburgite.
d.—Dunite. *t.*—troctolite, allivalite.
o.—Olivine gabbro and olivine norite.

A point on this diagram represents a rock containing felspar, pyroxene, and olivine in amounts proportional to its distances from the sides opposite to angles *F*, *P* and *O*, respectively. The chemical composition varies regularly round the triangle.

In passing through the points *F P O* the percentage of alumina and lime, and the ratio Fe: Mg steadily decrease, the sum of Fe and Mg rapidly increases, the percentage of silica rises slightly from *F* to *P*, and falls rapidly from *P* to *O*.[1]

The plutonic inclusions of Dundas lie within the triangle *a p l* or along the line *p d*. Rocks lying in the lower triangle *a l d* have not as yet been found in the quarry. This corresponds to the general rarity of rocks of this mineralogical

[1] See average Analyses of Anorthosite (*F*) Websterite (*P*) and Dunite (*O*). R. A. Daly, Proc. Amer. Acad. of Arts and Science, Vol. XLV, No. 7.

composition; gabbros, pyroxenites and peridotites are not uncommon, troctolites and allivalites are rare. This is explained by Harker as due to the effect of differentiation with mutual repulsion in a system of more than two components. A pure olivine-felspar magma or a mixture of felspathic and peridotitic magmas differentiates along the line *F O*. If pyroxene be present in notable amount, this differentiation line breaks almost completely, and the rocks are formed adjacent to the lines *F P* and *P O*, as in the Dundas series. The presence of biotite or hornblende in the olivine-felspar magma has much the same effect.[1]

The range of the different minerals is also of interest. The presence of rhombic pyroxene may be considered as partial evidence of deficiency of lime in the magma. Coincident with this we have the alumina, unable to enter felspar, forming spinels with the ferric oxides. The association of spinels and rhombic pyroxene is a marked though not a constant feature of this series of rocks. The entry of lime into the monoclinic pyroxene, leaving alumina free to combine with ferrous oxide and magnesia to form pleonaste, is a reversal of the normal order of chemical affinities.[2] That an excess of alumina is present in the more basic members is shown by the occurrence of picotite rather than chromite in the almost limeless dunites. In accordance with the increase of the ratio MgO : FeO as we proceed in the direction *F P O* we find hypersthene, augite, and augitic diallage to be, in general, characteristic of the gabbros and pyroxenites, enstatite and diopside-diallage of the pyroxenic peridotites and in the dunites the ratio reaches a maximum.[3] Further, out of a group of fifty slides of plutonic rocks, the

[1] Harker, Geology of the Smaller Isles of Invernesshire, 1908, p. 90.

[2] Quantitative Classification of Igneous Rocks, p. 190.

[3] Compare J. H. L. Vogt, Ueber anchieutektische und anchimonomineralische Eruptivgesteine, Norsk. Geol. Tidskr. Vol. I, 1905, and Harker Natural History of Igneous Rocks, p. 372.

major portion of the collection studied, twenty-one fresh or altered dunites or pyroxenic peridotites and pyroxenites contained picotite and no pleonaste or ilmenite. Six slides of the quartz carbonate rock, later to be described as altered dunite, all contained picotite and no ilmenite. Eleven rocks all containing felspar and including anorthosites, gabbros, hypersthene gabbros, olivine gabbros, and gabbro very poor in felspar, all contained pleonaste (six with graphic intergrowth of pleonaste and pyroxene). They contained no spinel or ilmenite, with the possible exception of a single very small isotropic brown grain, perhaps chromite in the hypersthene of one rock. Three rocks (two gabbros and one hypersthene gabbro) contained ilmenite and no spinel; and nine slides of anorthosite, ophitic gabbro contained no primary ilmenite or spinel. In only one rock did picotite and pleonaste definitely occur together. This is not plutonic but a hypersthene gabbro porphyry with granophyric pleonaste. It contains a large diallage crystal almost an inch in diameter, pseudomorphs after olivine, and in a section one large grain of picotite. It seems therefore, by no means certain that the picotite with the diallage in this rock are not xenocrysts derived from a coarsely crystalline diallage peridotite broken or partially absorbed by the intrusion of gabbro porphyry. The conclusion seems justified that a brown spinel is rarely if ever a constituent of a felspar-bearing member of the Dundas series of plutonic rocks. This rule cannot be applied universally, picotite or chromite may be present in gabbro elsewhere.[1]

The structure of the rocks present some features of interest. The grainsize is fairly constant, 4 mm. to 2 mm.

[1] Rosenbusch, Mikroskopische Physiographie der Mineralien und Gesteine, 1907. Bd. II, t. i, p. 336. This distribution of spinels here described has been shown by Mr. J. A. Thomson to hold for a similar series of inclusions in the basalts etc. of the Mount Erebus series in the Antarctic.

in the gabbroid rocks and pyroxenites, and slightly less in the peridotites, are the dimensions of the essential minerals, half a millimetre being perhaps the average diameter of an accessory mineral grain, ilmenite and some picotites are larger, pleonaste and the rest of the picotites smaller. There are no idiomorphic minerals in the rocks, but an order of crystallisation can be made out by the relative idiomorphism of the minerals. In anorthosite the pyroxene diallage appears to have formed first, though this is not quite definite, for in the pyroxene there is sometimes a little spinel (for the significance of which see later). In a diallage gabbro composed of about sixty per cent. of felspar and forty per cent. diallage, the latter is most distinctly ophitic enclosing large plates (but not laths) of felspar (see fig. 7).

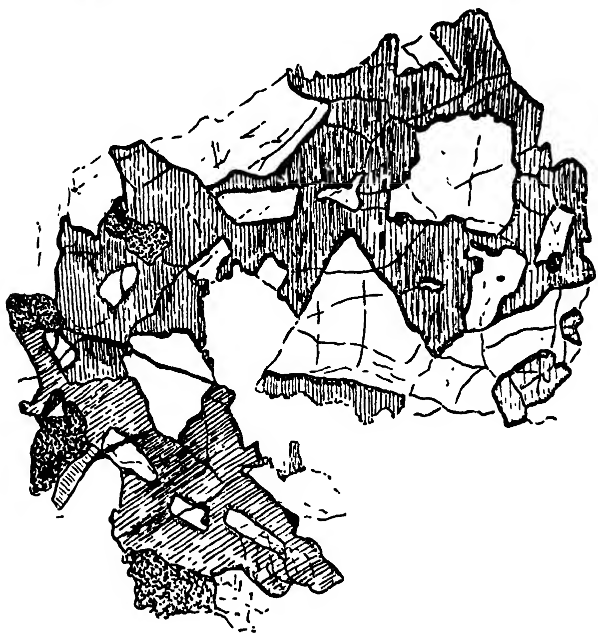


Fig. 7.—Ophitic structure in gabbro plagioclase and diallage.

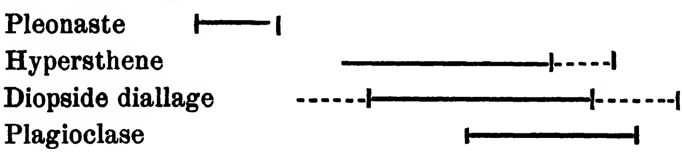
The presence of iron ores in the magma appears to affect the order of consolidation. In a rock approximately of the

following composition:—

Augite	60
Plagioclase	35
Ilmenite	5
	100

the periods of consolidation overlapped greatly. On the whole the order appeared to be ilmenite, felspar, augite. As this rock showed a marked tendency to segregation of the pyroxene, the slide may not be quite typical. It is probably lower than the average in felspar.

The spinel-bearing gabbros bear features of the greatest interest which will be described later. They are of two classes, those without granophyric intergrowths, some of which have a slightly banded structure, and which have in general crystallised in the scheme below:—



and secondly, the rocks with a granophyric intergrowth of pleonaste and pyroxene.

In the pyroxenites and peridotites, picotite is always the first formed mineral, with olivine slightly earlier than pyroxene. The grains are about a millimetre in diameter, some rocks however have a grain size more than twice this; a variety is found in a dunite with finely granular olivine about ·2 mm. with phenocrysts of enstatite and rarely olivine 1 mm. in diameter. The strained nature of the enstatite crystals and the approximate parallelism of adjacent granules of olivine indicate that this is a normal peridotite which slight shearing has rendered granulitic in those portions composed of the brittle mineral olivine. (See *Plate 34*, fig. 2.)

THE TYPES OF PLUTONIC ROCK.

The various types of plutonic rocks found at Dundas may now be briefly described. Their range in mineralogical composition has been already discussed. It is noticeable that in certain types, particularly the peridotites and basic gabbros, considerable variation exists in the proportions between the constituent minerals, so that two sections of the same specimen may fall, if considered alone, into different varieties of rocks. This is due to the tendency of the pyroxene to form aggregates. In normal gabbros the tendency is less marked.

Anorthosites.—These rocks are composed almost entirely of basic labradorite with a little diallage, occasionally with spinel intergrowths. Such specimens as have been studied (they are not very common) have been much altered by schillerisation of felspar and diallage, and usually by the alteration of the latter to chlorite, biotite and smaragdite. By increase of pyroxene these pass into *gabbros*. The following is the chemical composition of a gabbro rich in basic felspar (A). With it is the analysis (B) of a gabbro from Oberbeerback in the Odenwald.[1]

	A.	B.
SiO_2	48·86	47·97
Al_2O_3	21·88	22·16
Fe_2O_3	1·83	1·12
FeO	4·87	4 10
MgO	3·79	4 58
CaO	11 69	11·96
Na_2O	3·30	3·23
K_2O	·20	·29
H_2O –	1·04	·15
H_2O +	1·22	1 90
TiO_2	1·26	·44
P_2O_5	·28	1·14
MnO	·34	—
NiCo	·10	—
SrO	p.n.d.	—
FeS_2	—	·35
	100·66	99 39

	A.	B.
Orthoclase	1·11	1·67
Albite	27·77	27·25
Anorthite	44:48	45·31
Diopside	9·55	5·62
Hypersthene	7·16	5·68
Olivine	2·82	6·47
Magnetite	2·55	1·62
Ilmenite	2·43	·76
Apatite	·67	2·69
Pyrites		·35
Water	2·36	2·05
	100·90	99·47

[1] Rosenbusch, Elemente der Gesteinlehre, 1901, p. 155, No. 13.

Both these analyses fall into the division II. 6. 4. 3. with magmatic name of Hessose. Microscopically the felspar was determined to be bytownite (this is confirmed by the analysis), the diallage shows the development of inclusions in the (010) plane as well as in the (100)—the pseudo-hypersthene of Dana.[1] It is weakly pleochroic with 𝔞 and 𝔟 yellowish-green, and 𝔠 greenish-grey. In places it shows a well marked ophitic character (see fig. 7) a considerable amount of alteration has taken place with the formation of green mica and matted chlorite. A little calcite is present. This rock is almost a *eucrite*.

Gabbros and hypersthene gabbros occur with rather more acid plagioclase (labradorite) in which ilmenite is present. The constant association of this mineral with a pale green serpentine with vermicular intergrowths of calcite is very noticeable. The augite is not diallagic, and is of pale pink-brown colour. The hypersthene is quite subordinate.

Pleonaste-bearing Gabbroid Rocks.

Among the most interesting groups of rocks to be found in the Dundas quarry are a group of gabbroid inclusions characterised by the presence of a bluish-green spinel. Thanks to the kindness of Mr. C. A. Süssmilch and Mr. R. E. Priestly, who have lent me sections of these rocks, I have been enabled to study a continuous series of them. They fall into two distinct divisions—those in which the pleonaste is granophyrically intergrown with the pyroxene, and those in which it forms merely irregular grains. In the latter division it is always the first mineral to crystallise. The pyroxene is pinkish augite or diopside-diallage, or hypersthene, paler in colour in those rocks in which it is more abundant. In the following table is given the approxi-

[1] Cited by Judd, Quart. Journn. Geol. Soc., 1885, p. 380, see also *loc. cit.* Plate xi.

mate mineralogical composition of a series of these estimated by rough comparison only of their areas in section. The order of consolidation is given in the last column, where *P* = pleonaste, *R* = rhombic pyroxene, *M* = monoclinic pyroxene, *F* = felspar, *D* = decomposition product of indeterminate origin :—

Rock.	*F*	*M*	*R*	*P*	*D*	Order of crystallisation.
a	60	35	4	1	0	P R M F
b	50	36	12	2	0	P R M F
c	27	64	6	3	0	P R M F
d	18	38	42	2	0	P M R F
e	12	82	1(?)	2	5*	P M F

* Probably after hyperstbene.

Estimating in the same rough way the composition of the granophyric rocks we obtain the following figures. O = olivine, either fresh, or indicated by decomposition products.

Rock.	*F*	*M*	*R*	*O*	*P*	*D*
f	96	3·5	0	0	·5	
g	95	3·7	1	0	·3	
h	75	16	7	9	2	
i	66	23	5	3	3	
j	55	25	10	7	3	
k	10	72	6	0	2	10

From these tables it will be seen that the central members of both series are richest in spinel and that in the granophyric series olivine is present in greatest abundance in the rocks lying in the centre, while absent from the non-granophyric series. Using the triangular diagram again (fig. 6) we may say that the non-granophyric rocks lie on the line *a p* the granophyric rocks in the triangle *a o p*. The structure of the intergrowth is peculiar. On first sight it would appear that the felspar was moulded on the pyroxene containing the pleonaste, but the fact that the pleonaste fibres start perpendicularly out from the junction

surface between pyroxene and felspar, suggest that this surface existed prior to the crystallisation of the pleonaste. The pleonaste fibres as they pass into the centre of the pyroxene areas become thickened and twisted, bending about in a peculiar fashion, and irregular blebs of pleonaste may lie across the boundary surface between two pyroxene crystals. (See *Plate 34*, fig. 3, also fig. 8.) Moreover there

Fig. 8—Olivine gabbro with pleonaste.

are sometimes little "chutes" of pyroxene containing spinel running out between two felspar crystals. The pleonaste in these rocks does not occur unassociated with pyroxene, it does not, for instance, form independent inclusions in the felspar. All of these observations show that the pleonaste has formed subsequently to the felspar, a reversal of the normal order of consolidation.[1]

A very interesting feature occurs in a slide kindly lent me by Mr. J. L. Froggatt; here four pyroxene individuals, apparently all monoclinic, have intercrystallised in a poikilitic fashion, and pleonaste has crystallised in a semi-grano-

[1] Harker, Natural History of Igneous Rocks, p. 205.

phyric manner through the whole. Hypersthene is present also in the rock, but does not include pleonaste. Olivine is absent. (See fig. 9).

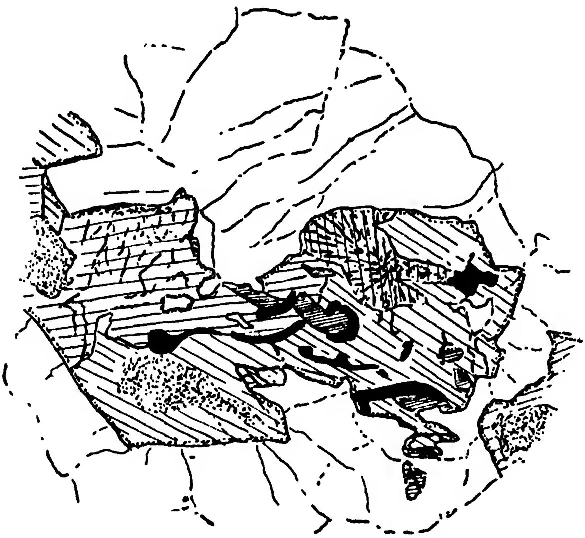


Fig. 9—Intergrowth of four pyroxene individuals with pleonaste.

From a chemical point of view the occurrence of pleonaste associated with monoclinic pyroxene is a reversal of the normal order of chemical affinities for the alumina has entered into combination with magnesia and ferrous oxide, leaving the lime to enter pyroxene. The very pale colour of the pyroxenes, especially when these are most abundant, indicate that for rocks of this basicity the ratio of magnesia to iron is abnormally high, and that ferric iron is unusually low. It is here suggested that these rocks result from an admixture of peridotitic magma with the partially crystallised differentiation products of a gabbroid magma, or by resorption of felspar by the still molten olivine in a crystallising felspar-olivine magma. By the solution of felspar in the peridotitic magma those irregular spaces are formed in which the syntectic melt crystallises. By reactions in the

syntectic, pleonaste, enstatite and diopside are produced. Pleonaste separates at once, forming fine fibres standing perpendicularly to the boundary of the solution-spaces, or irregularly shaped blebs in the melt, which crystallises as pyroxene. Making the simplifying assumption that the felspar is anorthite this reaction can be expressed in the following formula:—

$$m\,CaO,\ Al_2O_3,\ 2\,SiO_2\ +\ n\ 2\,(Mg.\ Fe)O,\ SiO_2\ =$$

Anorthite. Olivine.

$$\begin{array}{ll} (m-1)\{CaO,\ Al_2O_3,\ 2SiO_2\} & \text{Anorthite} \\ +\ Al_2O_3,\ (Mg,\ Fe)O. & \text{Pleonaste} \\ +\ CaO, (Mg, Fe)O, 2\,SiO_2. & \text{Diopside} \\ +\ 2\{(Mg,\ Fe)O,\ SiO_2\}. & \text{Enstatite} \\ +(u-2)\{2(Mg,Fe)O,\ SiO_2\}. & \text{Olivine} \end{array}$$

That the spinel rocks do not always contain spinel, enstatite and diopside, in just the proportion indicated by the formula may be due to the original presence of pyroxene in the felspathic or peridotitic magma, probably the latter. So far, however, I have been unable to distinguish between primary and secondary pyroxene in the microscopic examination. Another method of production of pyroxene more active in the more felspathic rocks, and apparently subordinate in the femic rocks may be expressed in the following formula:—

$$CaO,\ Al_2O_3, 2SiO_2 + 2(Mg, Fe)O,\ SiO_2 = \begin{cases} (CaO,\ (Mg, Fe)O,\ 2SiO_2 \\ Al_2O_3, (Mg, Fe)O,\ SiO_2 \end{cases}$$

Anorthite. Olivine. Augite.

The assumption here made that the felspar has crystallised first is not without foundation. Pratt and Lewis[1] adduce evidence to show that in a basic magnesian magma the aluminous minerals crystallise first, quoting Williams observations on the felspathic peridotites of Maryland.[2] Harker

[1] Corundum and the Peridotites of Western North Carolina, North Carolina Geol. Surv., Vol. I, 1905. p. 148.

[2] Bull. U.S. Geol. Surv., No. 28, 1886, p. 53.

has noted in the allivalites of Rum that in anorthite-olivine rocks, when the anorthite is in excess, it has crystallised first.[1] Experimental work, according to Pratt and Lewis, shows the same order. To account for those rocks in which pleonaste occurs without granophyric intergrowth we may perhaps suppose that they were completely remelted during the addition of peridotitic material and recrystallised in the more normal order, pleonaste being, as usual, the first mineral to form. But it must be noted that in these rocks, so far as yet studied, olivine does not occur. How far this may be a determining cause of the absence of the granophyric intergrowth is not clear.

It will be noted that the explanation here advanced for the origin of pleonaste is analogous to that offered for the occurrence of kelyphitic rings about olivine. Pratt and Lewis show that about olivine crystals in olivine felspar rocks there is sometimes "a three ply development, the layers, beginning next to the olivine, are as follows:—(*a*) enstatite... (*b*) diopside... (*c*) actinolite... Everywhere except in a thin layer next the anorthite the actinolite is intimately intergrown with irregular masses and tangled vermiculate stringers of pleonaste."[2] Dr. Adams, they say, regards the reaction rims as due to the interaction between olivine and the still molten plagioclose, but the authors cited suggest that the felspar may be the earlier. "Assuming that these rocks are intrusive masses, and that the anorthite represents a deep seated crystallisation, sufficient change in condition might have been produced by their intrusion into their present position to have caused the corrosion before cooling. This reaction would be quickly stopped, however, by the solidification of the rock, The products resulting from the combination of the aluminium,

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[1] Natural History of Igneous Rocks, p. 171.

[2] *Op. cit.*, *supra*, p. 147.

magnesium and calcium silicates, would therefore be limited to comparatively short distances from the original anorthite surface, and would appear in the solidified rock as mantles or sheets between the olivine grains and the anorthite."

The Dundas rocks differ in the absence of the actinolite and in the fact that in general the intergrowth does not lie round an olivine crystal but is self standing. In a few instances, however, the intergrowth does surround an olivine crystal.

When one seeks to find descriptions of similar rocks elsewhere, very little can be found. Holland mentions that in the pyroxenites of the charnockite series in India, the green spinel "occurs in irregularly shaped granules and sometimes vermiform blebs, associated invariably with lumps of magnetite and generally crowded with minute granules and dust of presumably the same substance."[1]

Messrs. Dupare and Pearce in describing the norites of Telai in the Urals, write "Les norites à olivine sont d'habitude pauvres en pyroxene et notamment en hypersthène; l'olivine par contre y est toujours predominante et de grande taille. Elle formait sans doute a l'origine des associations poecilitiques avec les pyroxenes ceux ci sont presque toujours fortment ouralitisèes, l'amphibole est à peine polychröique. La magnetite, exclusivment sideronitique est toujours très abondante. Ces roches sont characterisèes par *le grand developpment des spinelles, qu'on trouve en graines et en superbes associations micropegmatoides avec le pyroxene ou l'amphibole.* Les felspaths sont ici toujours très basiques, et appartiennent au groupe des labradorbytownites ou de l'anorthites. L'element noir reuni en grandes plages à individus multiples soudés par la magnetite sideronitique, est disseminé parmi l'element felspathique."[2]

[1] Memoirs of the Geological Survey of India, Vol. XXVIII, Pt. 2, "The Charnockite Series," p. 168.

[2] Recherches Petrographiques sur L'Oural Memoir II, Soc. Phys. et Hist. Nat. du Geneva, 1905, p. 458.

These two authorities give the only notices of the presence of pleonaste in granophyric or vermicular form, which I have been able to find, and neither of them describes rocks as simple in character as those of Dundas. We have, therefore, close to Sydney, a unique opportunity for the study of the origin of spinel in igneous rocks, and its physico-chemical characteristics. It is to be hoped, in view of such a work being undertaken here, that any one finding a spinel gabbro will present a portion of the specimen to one of the museums of this city, so that it may become available for future use.

Brief Descriptions of Particular Specimens.

a. Spinel both in felspar and pyroxene though preferring latter. Possibly this is due to the earlier crystallising pyroxene using the spinels for nuclei leaving a fairly clear field for the felspar. This latter is bytownite-labraborite.

c. Rock has a slightly banded arrangement of pyroxenes. They are just commencing to decompose peripherally. The felspar is labradorite. This may be classed as a hypersthene gabbro.

d. A very fresh rock with labradorite as the felspar. Rhombic pyroxene is slightly in excess of the monoclinic, thus causing the rock to pass over into the group of norites. Diallage structure is partially developed in the pale pinkish-brown augite. The rhombic pyroxene, without schiller structure," is practically an enstatite. (See Fig. 10.)

e. The predominant mineral is a colourless diopside with very slight trace of a diallagic parting. The development of the structure described on a previous page as probably due to an intergrowth of rhombic pyroxene is present to a small extent.

f. Felspar a basic labradorite; pyroxene a pale diopside only slightly diallagic, decomposing into chloritic material. The spinel is sometimes irregularly placed in the crystals, sometimes running perpendicularly to the boundary.

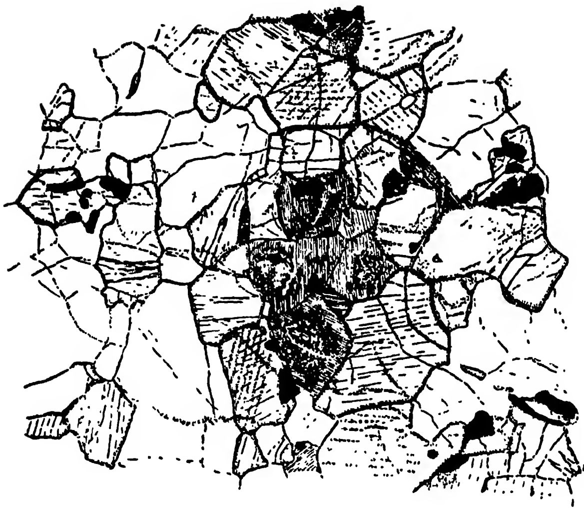

Fig. 10.—Pleonaste norite poor in felspar.

h. This most interesting slide was kindly lent me by Mr. R. E. Priestly. Olivine was present in some amount, though now it is entirely replaced by granular quartz, grey carbonates and greenish silicates. In one portion the olivine is irregular in outline and includes within it a grain of plagioclase, from which as from the surrounding felspar it is separated by a narrow band of diopside containing pleonaste. This surrounding of an olivine grain by diopside is of frequent occurrence in the slide and the outgrowth of pleonaste from the boundary of the plagioclase into the pyroxene crystal is very well marked. Both rhombic and monoclinic pyroxene may contain the pleonaste. In one instance olivine is separated from plagioclase by a large crystal of pleonaste. It is to be noted that the olivine does not appear ever to contain spinel. The plagioclase is a labradorite-bytownite.

i. and *j.* were kindly lent me by Mr. C. A. Süssmilch. *i.* contains a small amount of greenish decomposition product, probably after olivine, included in a large aggregate of

pyroxene. Rhombic pyroxene is subordinate to monoclinic pyroxene and both may contain pleonaste. In some cases this forms excessively fine granophyric intergrowth, at other times rather more coarse. The felspar is labradorite.

j. contains rather less felspar. It is noteworthy for the abundance of clear colourless olivine which is just commencing to form serpentine and talc (?) along the cracks; from the almost complete absence of magnetite it must be nearly pure magnesium olivine. Of the pyroxenes, diopside and enstatite are present, the latter in considerable amount, occasionally forming a large plate, in which diopside and olivine are set poikilitically. Pleonaste forms granophyric intergrowths occurring both in diopside and enstatite. If, however, there should be the two pyroxenes side by side, and pleonaste in one only of them, it will usually be enstatite. With the diopside there is developed the curious feature of a large lump of pleonaste outside the grain sending apophyses into the grain which terminate in a granophyric intergrowth, the distal ends run perpendicular to the bounding surface of the diopside against the plagioclase. In one instance, and the only one in the series of slides studied, the granophyric intergrowth spreads radially from a point within a pyroxene grain. The plagioclase is labradorite..

There is one rock which though perhaps not truly plutonic may best be considered here as it shows to perfection the granophyric intergrowth of pleonaste and pyroxene. Macroscopically it was noticeable as being of small grain size, and containing a large crystal of diallage, two centimetres in diameter (the source of the diallage studied in detail). Microscopically the texture is distinctly porphyritic, the phenocrysts being slightly titaniferous augite, hypersthene and labradorite. The pyroxenes are commencing to alter the augite to chlorite and amphibole, the hypersthene to

anthophylite (?) Schiller plates of a deep purple colour are also present to some extent in the hypersthene. A large chromite or picotite grain, together with a few small grains of rounded irregular shape is also present. Oval areas occur, composed at the centre of an aggregate of parallel green fibres and surrounded by a ring of radiating green fibres, probably chlorite. These seem to be the replacements of original olivine crystals. (See fig. 11.) In certain

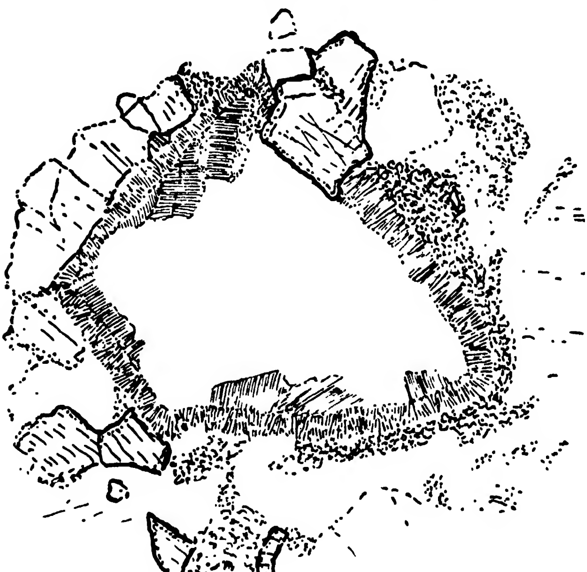

Fig. 11 —Pseudomorph after olivine in gabbro porphyrite.

of the phenocrysts of augite, usually those paler in colour, there is present a granophyric intergrowth of pleonaste, sometimes most beautifully developed. (See *Plate 34*, fig. 3) In a very few instances green spinel is present merely as simple grains. The ground mass of the rock is subordinate in amount to the phenocrysts. It consists of a fine grained aggregate of plagioclase with a little augite. The plagioclase is rarely twinned well, and is not definitely determinable. A few grains develop pericline twinning on so fine a scale as to resemble microcline.

The mode of origin of this rock is not clear. It seems most probable that it resulted from the solidification in a dyke of a mixture of two partially crystallised magmas. The presence of brown spinel with felspar, of large diallage crystals and granophyric phenocrysts are all unusual features. The rock may be termed a hypersthene gabbro-porphyry.

Pyroxenites.

A diallagite (see fig. 16) occurs which is composed almost entirely of diallage with a minor amount of enstatite. The enstatite occurs in rounded undecomposed grains, is

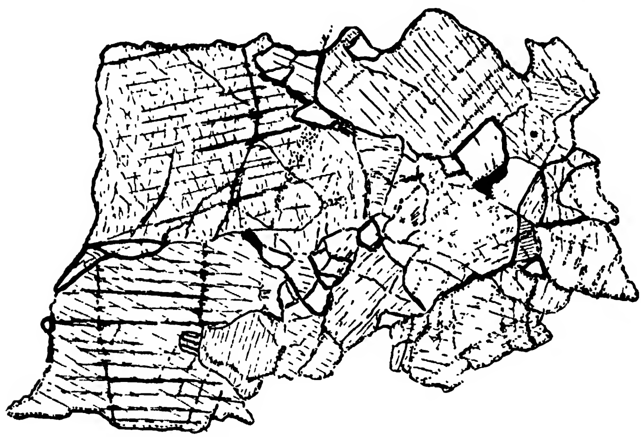

Fig. 12.—Diallage with enstatite and picotite.

the earliest product of consolidation. Moulded on the enstatite, but not poikilitically enclosing it, the diallage forms large platy crystals about four millimetres in diameter. It is pale brownish-green in colour in the section and without noticeable pleochroism. It is polysynthetically twinned parallel to 100, and contains finely laminar inclusions of hypersthene parallel to the clinopinacoid. Schiller inclusions are not well developed, but a few irregularly oxide-filled cavities occur in bands, and the cleavages often appear to be a little darkened by inclusions. A very few

grains of picotite and also a little calcite are present. An analysis of this rock was made and given below (A). With it is the analysis (B) by Mr. J. C. H. Mingaye, of the diallage rock in the volcanic pipe at Norton's Basin on the Nepean[1]:—

	A.	B.[2]
SiO_2	50 09	50·36
Al_2O_3	11·31	2·46
Fe_2O_3	1·91	4·26
FeO	3 09	4·41
MgO	13·83	20 76
CaO	15·63	6·25
Na_2O	1·92	·51
K_2O	trace	·09
H_2O-	·61	2·21
H_2O+	1·06	4·07
CO_2	·16	4·41
TiO_2	·95	trace
Cr_2O_3	·21	·04
NiCoO	trace	·31
MnO	·06	·29
BaO	—	·02
	100·83	100·38

Norms.	A.	B.
Orthoclase	—	·56
Albite	16·24	4·19
Anorthite	22·24	4·17
Diopside	42·37	—
Hypersthene	2·66	57·00
Olivine	11·16	—
Magnetite	2·78	6·26
Ilmenite	1·67	—
Chromite	·30	·07
Carbonates	·40	9·90
Quartz	—	10·92
Water	1·67	6·28
	101·49	99·35

The most unexpected feature in the Dundas diallage rock is the high percentage of alumina. A previous partial analysis of this specimen had been rejected as incorrect, chiefly because of this feature, but a re-analysis confirmed it, giving the figures shown. It is, however, not the highest recorded for diallage, though those with higher alumina have often much higher iron content and are poorer in silica. Some chrome diopsides have somewhat similar composition.[3]

But as the specimen on its boundary was intersected by basalt veins proceeding from the basalt in which it was

[1] An. Rep. Dept. Mines, 1908.

[2] Including traces of TiO_2. P_2O_5 –, SiO_2, LiO_2, V_2O_3 –; S, SO_3, Cl, and F are all absent.

[3] Dana, System of Mineralogy, p. 379, Analysis No. 40, and Hintze, Handbuch der Mineralogie, p. 1105, Analysis LIII.

included, though care was taken in choosing the sample, it is not impossible that it contains some basalt, which is rich in alumina. A certain amount of alumina is present, of course, in the spinel of the diallagite. The high percentage of quartz and carbonates in the Norton's Basin rock shows it also is impure. Mr. Card specially remarks on the difficulty of selecting a specimen free from secondary minerals.[1] The analyses shows that even after careful choice some carbonate was included.

Peridotites.

The peridotites are those rocks which contain predominantly olivine, with lesser amounts of pyroxene with spinel or chromite. Three types occur in the Dundas quarry.

Lherzolite.—This rock contains about forty-five or fifty per cent. of olivine, the remainder being made up of enstatite and diopside, the former slightly in excess, with a small amount of picotite. The alterations are those described previously. Particularly noticeable is the pilite (matted actinolite replacing olivine) which occurs in long bands in the rock, and in which is embedded perfectly fresh pyroxene.

Harzburgite.—This is composed of about seventy per cent. of olivine, with the remainder chiefly enstatite, a little diopside and brown picotite. This is more common than lherzolite. The alterations are a described above.

Dunites occur composed of olivine with very subordinate amounts of pyroxene, and always a percentage of picotite. A fairly fresh specimen was analysed with the following result:—

[1] Ann. Rep. Dept. of Mines N.S.W., 1908.

SiO_2	39·13
Al_2O_3	3·48
Fe_2O_3	1·83
FeO	7·58
MgO	42·15
CaO	·07
H_2O-	2·80
H_2O+	·80
CO_2	3·05
TiO_2	·16
Cr_2O_3	·20
NiCoO	·04
MnO	·21
	100·75

Norm.	
Olivine	72·14
Enstatite	16·02
Corundum	3·48
Magnetite	2·60
Ilmenite	·30
Chromite	·30
Water	2·88
Co_2	3·05
	100·77

Mode.	
Olivine	54·80
Enstatite	19·31
Picotite	5·16
Magnetite	2·60
Carbonates	5 99
Serpentine	9·94
Silica	·96
Water	1·58
	100·34

Calculating the position of this rock in the American Classification we find it falls in V 1. 4 1. 1.; and for this rang and sub-rang the names Dundase and Dundose are suggested. These seem peculiarly appropriate as indicating both the locality of this rock and its affinity with the neighbouring rang and sub-rang Dunase and Dunose, the less aluminous olivine rock. The mode of the rock was calculated on the following assumptions:—

1. Magnesia and ferrous oxide enter olivine, enstatite, picotite and carbonates always in the proportion in which they occur in the bulk analysis.
2. Titanic oxide plays the part of silica in the olivine molecule.
3. The rock was originally without ferric oxide. The magnetite therefore is an index of the amount of olivine that has been converted into serpentine.
4. The olivine was the only mineral attacked by the carbonic acid.
5. The excess of the silica set free by carbonation of olivine over that absorbed in serpentinisation remains in rock as quartz, chalcedony or opal.

It is probable that none of these assumptions is entirely true, No. 3 especially is unlikely, for the picotite may con-

tain ferric iron; the picotite of this rock as calculated would have the following composition,

Al_2O_3	67·2
FeO	4·1
MgO	24·7
Cr_2O_3	4·0
	100·0

This mineral has previously been recorded as chromite, but the constant low percentage of chromium through the rocks studied, dunite, diallagite and quartz-carbonate rock, and the considerable amount of alumina in the first and last of these agree in referring the mineral to picotite. It has been shown frequently that the two minerals are but the end points of a series joined by a great number of specimens of intermediate composition. These have recently been discussed by Harker,[1] and Pratt and Lewis.[2]

Altered Peridotites.

Serpentine.—A beautiful example of olivine serpentine occurs with typical mesh structure. (*Plate 34*, fig. 4.) The cracks in the olivine are filled with magnetite and dusty carbonates, while the meshes are lined with colourless serpentine in the centre of which is often a rounded isotropic grain of very low refractive index—this is opal. Residual olivine grains also occur. A little green faintly pleochroic chlorite of birefringence greater than that of the serpentine is also present. A few unaltered grains of diallage are scattered about and a number of dark brown grains of picotite.

Another very interesting alteration is shown in a harzburgite vein in a dunite. The pyroxene (enstatite) is passing into a pleochroic red-brown fibrous mineral of high birefringence, which seems to be anthophyllite. The olivine has

[1] Tertiary Igneous Rocks of Skye, 1904, p. 70.
[2] On Corundum and the Peridotites of Western North Carolina, Rep. of Geol. Survey of N.C.. Vol. I., 1905, p. 374.

changed into pale green faintly pleochroic fibres with straight extinction which again seems to be anthophyllite though of a much less ferriferous type. With it is associated a good deal of actinolite. The central portion of the olivine pseudomorphs is either talc or finely interlocking quartz grains. Occasionally the whole pseudomorph is made up of interlacing amphibole fibres with irregularly scattered quartz grains. The spinel is a remarkably greenish-brown and is probably intermediate in composition between picotite and pleonaste.

Talc rock.—Another mode of alteration of peridotite is to a rock composed of pale green non-pleochroic, but highly birefringent talc in areas separated by bands of dusty carbonate, evidently the survival of the intergranular cracks. Each of these areas is made up of a complex of minutely interlacing fibres and plates of talc showing mutual compensation. Here and there the rock becomes a darker green-brown and is fibrous and pleochroic. The extinction is usually straight and the double refraction lower than that of talc. This is perhaps chlorite. There are a few grains of diopside-diallage and some picotite. This rock was once a dunite.

An interesting slide shows how greatly the metamorphosing condition varied in a small distance. A section of dunite is in its central portion almost unaltered. Serpentinisation is commencing in the usual way. One end has passed completely into the green talc through an intermediate band of darker pleochroic green. The other end is in an advanced stage of serpentinisation, a little carbonate and green silicate is present with it.

Quartz-carbonate-picotite rock.—A very noticeable rock is found usually in the breccia. It is dull white or pale grey in colour, and studded with black grains of spinel. Or it may be grey with cloudy white or pale brown patches,

and a green material is present in varying amount. Its grains are about one and a half millimetres in diameter, rounded and firmly cemented. Under the microscope this is seen to be composed of quartz in plates, or small interlocking grains or pseudomorphous after serpentine. With this is a greater or less amount of carbonate in bands, irregular patches and filling intergranular crevices. In the general arrangement of the grains the rock shows an absolute identity with dunite, and the minerals present are all those which have been proved to be alteration products of olivine. Moreover the presence of picotite is itself evidence of the rock being originally a peridotite. The opinion was then formed that this rock was an altered dunite. This was conclusively proved to be correct by the discovery in the basalt of the neck (in which silicating and carbonating waters have not such free circulation as in the breccia) of a boulder of dunite altered peripherally into quartz rock with a minor amount of carbonate and green silicate. The differences in the structure of the quartz in this altered rock appears to be explained by considering the state of alteration of the dunite prior to its silicification; the different forms of quartz represent alternatively replacements of olivine, serpentine, and talc. A specimen was chosen rich in picotite and free from the green silicate, and was analysed with following result:—

SiO_2	46·29
Al_2O_3	4·66
Fe_2O_3	1·93
FeO	10·10
MgO	7·13
CaO	9·36
H_2O	·11
CO_2	19·34
TiO_2	·12
Cr_2O_3	·24
MnO	·19
NiCoO	·05
	99·51

Calculated Mineral Composition.

Quartz...	46·29
Calcite...	16·70
Siderite	14·03
Magnesite	12·78
Picotite	7·44
Haematite	1·93
Rutile	·12
Water	·11
	99·50

In the calculation of the mode the assumption was made that all the iron in the ferric state was in haematite, that all the alumina was in the picotite, and that the ratio of magnesia and ferrous oxide in the spinel was identical with that in the picotite of the analysed dunite. The very small amount of alumina effectively disproves the former presence of anorthite in any considerable quantity, more especially as the large amount of spinel and small percentage of chromium show how high must be the alumina content of that mineral. As might be expected, a good deal of lime has been brought in by the carbonating solutions.

A quartz-carbonate rock occurs which has been derived from a harzburgite. It consists of enstatite and diallage, both perfectly fresh, embedded in a mass of finely granular quartz, separated into major grains by layers of dusty carbonate. Picotite is present split by fissures which have been filled by carbonate also. Small veins of basalt are present containing minute flakes of biotite.

These observations throw considerable doubt on the determination[1] by previous workers of a chromite-anorthite rock. The chromite is probably picotite, as shown by the chemical analyses, though this distinction was not possible by the methods used in the earlier determination. Its occurrence makes the presence of felspar very improbable. Moreover in their account of the microscopic features of the felspar, they do not mention that it is twinned, or biaxial, or even showing cleavage. They specially note its resemblance in shape and cracking to the felspars of a troctolite. Further they note the presence of the greenish silicate, and also remark that in hydrochloric acid the mineral effervesces briskly. Their specific gravity determination of the "anorthite" would also be given by an

[1] Proc. Roy. Soc. N.S.W., 1893, p. 403 et seq.

appropriate mixture of quartz and carbonates. The presence of fresh diallage is quite in keeping with the rock last described. The conclusion seems justified that the rock studied by these authors was a peridotite with porphyritic diallage. The green and brown rock mentioned as occurring with the chromite-anorthite rock is also proved to be an altered dunite. A section of a green and white rock examined microscopically was composed of finely divided quartz clouded with talc stained green (by chrome oxide ?), and large areas of cloudy dust-like carbonates, extending into long bands separating the quartz-talc material into roughly rounded areas and containing limonite.

Picotite also occurred surrounded by a green-stained area. Graduations from this rock were also found. They occur in the most exposed positions and are the final stages in the alteration of a peridotite. This all confirms the opinion expressed by the Rev. J. Milne Curran, that " the chromite (picotite) occurred in much altered serpentine, or closely related ultrabasic rock."[1]

[Note added while this paper was passing through the press. From Mr. Arthur Coombe, I have received a specimen of an exceptionally coarse grained gabbro from Dundas. It is an olivine gabbro, in which the felspar is bytownite, and the olivine has been converted into a quartz-mosaic, with a little dusty carbonate. Surrounding the olivine was pyroxene, converted almost entirely into chlorite, and containing an intergrowth of pleonaste in the manner described previously. Some diallage crystals pass into a single pseudomorphous crystal of chlorite.]

Included Rocks of Dundas other than Plutonic.

Olivine dolerite.—This rock is rather rare; it has been found in the basalt in just the same way as the plutonic

[1] Geology of Sydney and the Blue Mountains, 1898, p. 262.

inclusions. It is composed of tabulate plagioclase crystals, large olivines, and granular titaniferous augite, with considerable ilmenite. Long prisms of apatite are very abundant. A striking feature of the rock is the occurrence of ilmenite wrapping round plagioclase crystals. Along the cracks in the olivine a peculiar mineral is forming. It is brilliantly birefringent with a strong pleochroism in tints ranging from a foxy-brown to yellow-green, and extinguishing parallel to its length. This seems almost certainly to be iddingsite. On either side of the iddingsite is a narrow green band possibly chlorite, and frequently this again is bordered with quartz. A narrow streak of dusty carbonate occupies the centre of the band. In the meshes of the network of cracks the olivine is sometimes unaltered, sometimes replaced by carbonates, sometimes by a felted mass of interlacing fibrous amphibole, actinolite and anthophyllite (?), somewhat resembling the pilite of Becke. That this alteration is accompanied by expansion is indicated very prettily in one spot by the bending outwards of the end of a felspar lath that abuts on to the olivine crystal. Another striking feature is the occurrence of beautifully spherulitic chlorite. The order of crystallisation is peculiar; apparently it is as under:—

Apatite |—|
Olivine |—|
Augite |———|
Plagioclase |———|
Ilmenite |—— ----------- ——|.

Where basalt occurs in small veins in the rock it contains a little biotite in small brown flakes. In a dolerite inclusion from Dundas found in the collection of the Adelaide University, hour-glass structure was observed in some of the prismatic augites.

The Breccia.—The breccia itself does not call for much remark. On the circumference of the pipe it is exceedingly

altered as are all the included rocks. In the centre it is grey-green in colour and closely resembles the breccia filling the Hornsby neck. It is made up of fragments of shale, sandstone, quartzite, conglomerate, plutonic rock and basalt. Adjacent to the basalt intrusion it is locally hardened into a dense grey or brown and black rock. The microscopic structure of this rock reveals many interesting points. It is composed of quartz grains cemented by a chloritic material, fragments of shale and chert, and also of basalt. The most striking feature of the basalt is its well marked flow structure. Two types occur, the one holocrystalline the other hypocrystalline. The latter is composed of plagioclase laths, (rather decomposed) arranged in a parallel direction and set in a deep brown glass. In this also are idiomorphic olivine crystals changed to iddingsite, forming a single plate placed transversely to the length of the crystal and with strong pleochroism, the colour changing from pale yellow-brown to deep green. Some more rosette like aggregates of fibres or flakes of similar pleochroism replace other crystals of olivine. These may be iddingsite also. With this a varying amount of carbonate is usually present.

The holocrystalline type contains parallel laths in a finely granular mass of augite and magnetite. This latter mineral is also aggregated into long bands parallel to the general flow direction. Iddingsite after olivine is also present. These crystals were beautifully idiomorphic and arranged parallel to the flow.

This rock is carbonated easily. The first sign of this is the production of a white mottling on the grey rock. These white areas are due to the carbonation of the olivine phenocrysts and of the pyroxenes that cluster round them. The magnetites pass into siderite and finally we have plagioclase laths set in a fine carbonate dust. Such a rock

looks like a hardened cream coloured claystone, though without cleavage or jointing. In a specimen of such a rock was found a small fragment of an altered peridotite.

From Mr. Arthur Coombe I have received a specimen of another type of basalt also found as inclusions in the breccia. I have, myself, also noted it in breccia by the road at the south entrance to the quarry. At first sight it appears as an oolitic limestone, and is scratched readily. The "oolites" are green, and about two or three millimetres in diameter. On sectioning, the rock proves to be a holocrystalline, pilotaxitic basalt, containing much calcite. The augite was finely granular and is almost completely decomposed. Decomposing titaniferous magnetite is very abundant. Small flakes of brown mica are common. The "oolites" are wrapped round by felspar laths and are filled either by very faintly coloured chlorite in beautiful radiatng aggregates, or lined with chlorite hemi-spherulites, the central portion being composed of a single or twinned crystal of calcite, either unbroken, or dotted through by small spherulites of chlorite. Dr. Woolnough suggests these "oolites" were steam filled vesicles, which expanding, when the pressure was released by eruption, forced aside the already formed felspar laths, thus causing them to appear as if wrapping round the chlorite and calcite. The idea that these areas are pseudomorphous after olivine is negatived by their approximately spherical shape. This same shape also shows that the enlargement of the vesicles continued after active flow had ceased, otherwise they would have been more amygdaloid.

The Basalt.

The basalt that fills the plug and runs in dykes out from it is that which has been chiefly used for road metal. It has been described briefly by Mr. G. W. Card.[1]

[1] Rec. Geol. Surv. of N.S. Wales, 1903, Vol. VII, Pt. iii, p. 229.

It consists chiefly of felspar laths (labradorite) with prismatic or granular titaniferous augite, finely crystallised magnetite and small phenocrysts of olivine. These last are passing into colourless highly doubly refracting talc. Flow structure is not well developed as a rule, though some slight trachytic arrangement is noticeable among the felspar. Chlorite replaces augite in the more weathered specimens and a little dusty carbonate may be present. The analysis shows that the rock is more closely related to the nepheline basalts than to the normal basalts, but I have not been able to determine the presence of nepheline in its almost isotropic base, nor was it noted by Mr. Card.

(A) Dundas basalt analysed by H. P. White[1]

(B) Average basalt (161 basalts, 17 olivine diabases, 11 melaphyres, and 9 dolerites).[2]

(C) Average nepheline basalt (16 specimens.

	A	B	C
SiO_2	45·88	49·06	44·20
Al_2O_3	17·16	15·70	15·64
Fe_2O_3	3·03	5·38	4·35
FeO	7·57	6·37	6·14
MgO	6·26	6·17	8·89
CaO	7·20	8·95	9·74
Na_2O	4·08	3·11	4·03
K_2O	1·78	1·52	1·83
H_2O-	·88	1·62	2·67
H_2O+	3·17		
CO_2	·60	—	—
TiO	2·24	1·36	1·64
P_2O_5	·19	·45	·68
SO_2	·09	—	—
ClF	·02	—	—
Cr_2O_3	·01	—	—
V_2O_3	·03	—	—
MnO	·24	·31	·19
NiCoO	·05	—	—
BaO	·13	—	—
	100·61	100·00	100·00

Norm of A.	
Orthoclase	10·56
Albite	23·58
Anorthite	23·63
Nepheline	5·11
Nosean	·70
Diopside	9·21
Olivine	14·06
Magnetite	4·41
Ilmenite	4·26
Apatite	·34
Water	4·05
CO_2	·60
	100·51

Classification
II 5. 3. 4.
Magmatic Name
Andose.

[1] (A) Rec. Geol. Surv. N.S.W., *loc. cit. supra.*

[2] (B and C) quoted from R. A. Daly, Average Chemical Compositions of Igneous Rock Types, Proc. Am. Acad. of Arts and Sciences, Vol. XLV, No. 7, Jan. 1910, Averages No. 40 and 69.

Relations between the Basalt and Inclusions.

a. *Sedimentary.*—The most noticeable feature of this group of reactions is the effect on the basalt produced by the presence of xenocrysts of quartz. The grains are frequently surrounded by a ring of exceedingly minute prisms of diopside. This phenomenon has been noted in both the older and the newer volcanic rock of this quarry.

b. *Igneous.*—It has been suggested that the rounded nature of the xenoliths was due to the corrosive effect of the basalt magma.[1] It is therefore of interest to examine closely the actual boundary between the basalt to seek for direct evidence of such an absorption. This seems to be indicated by the following facts. Angles of plagioclase do not often remain sharp in the basalt, on the other hand projections of augite into the plagioclase are frequent, and inclusions of xenocrysts of augite may be met with further from the boundary than xenocrysts of plagioclase, and are more common. (See *Plate 34*, fig. 5.) It seems reasonable to conclude, therefore that there was a strong absorption of plagioclase by the basalt magma along the line of contact, augite being absorbed less freely. When pyroxenites have been shattered on their margins the basalt penetrates into the cracks in long narrow veins. In such veins tiny flakes of biotite sometimes form in the basalt. There is also frequently a considerable segregation of magnetite or ilmenite in the basalt around an inclusion.

Hornsby Rocks.

The Breccia is green or greenish in colour composed of a very fine grained ground mass, in which are imbedded fragments of basalt or plutonic rocks, quartz grains, and pebbles, calcite, bitumen, *et cetera*. Under the microscope the breccia appears to be largely composed of quartz grains, either clear and large, probably derived from a sandstone,

[1] Prof. David, Watt, and Smeeth, Proc, Roy. Soc. N.S.W., 1893, p. 403.

or of the peculiar character shown by quartz replacing the olivine of peridotites. Fragments of chert also are present and grains of plagioclase. This is all set in a very finely granular aggregate, probably of kaolin and carbonates. This is dark and cloudy, and is dusty with very fine black opaque particles. Chlorite (pennine) is also present. Calcite forms veins through the rock, but some areas may represent limestone fragments. The plutonic inclusions in it are rare. I have noticed, as before mentioned, a peridotite containing fresh olivine and flaky pyroxene (wehrlite?), also a rock which resembled a gabbro, but proved to be composed of chlorite (much oxidised) replacing pyroxene, and carbonates possibly after olivine. In this were a few quite undecomposed grains of diopside and olivine. There was no spinel. A tiny flake of serpentine was found, about the size of a finger-nail; on sectioning this proved to be antigoritic, and very like the Gundagai serpentine in some respects. It is composed of large flakes of antigorite of a pale yellow-green in colour, rather twisted and stained, set in ground mass of little flakes of serpentine arranged nearly perpendicularly to one another—the "knitted" structure generally, though not always, indicating derivation from a pyroxene.[1] In addition there is also a large mass of finely dusted magnetite, occuring in irregularly bounded areas and several large compact grains.

A very interesting inclusion of essexite was found, only just sufficient to allow of a section being made. It is fairly decomposed. The predominate mineral is plagioclase (labradorite) in tabular crystals. It is decomposing with the formation of chlorite. In very much smaller amount is orthoclase in dull decomposed tabular crystals. The ferromagnesian minerals were varied. The most abundant is biotite in large flakes with a strong pleochroism ranging

[1] Professor Bonney and Miss Raisin, Quart. Jour. Geol. Soc. 1905, p. 700.

from red-brown to pale yellow-brown. Nearly as abundant as the biotite is a purple titaniferous augite, generally in roughly prismatic grains with a high extinction angle, occasionally ophitic. It is often wrapped round by the biotite, which in such instances is also partly ophitic. Hornblende also occurs with strong pleochroism (brown to red-brown) in almost idiomorphic crystals which may be primary. Apatite is a very abundant accessory, occurring in long prisms; a few plates of ilmenite also are present. Chlorite is a very abundant decomposition product, occurring and replacing felspar, but also in large irregular patches not definitely after any one mineral. It is yellow green in colour, but where after biotite it is blue-green. Very fine grained dust like carbonates are also present.

The most common rock however is of a basaltic character, even in hand specimens it may be seen how very marked is the flow structure of the felspars, and sections show the rock to be hyalopilitic. (See *Plate 34*, fig. 6.) The felspars are in idiomorphic laths of labradorite, twinned on the albite and carlsbad and occasionally on the pericline law, which is less common for microlites, the mesostasis is of grey-brown glass containing octahedra and small skeleton crystals (plates) of magnetite, and green chlorite. This is sometimes in idiomorphic areas probably pseudomorphous after a pyroxene. Some carbonates are scattered about in irregular grains or sharply defined rhombohedra. An analysis of the rock gave the following figures (A) from which the norm (B) and the systematic position was calculated:—

A		B	
SiO_2	48·30	Anorthite	31·14
Al_2O_3	20·20	Albite	28·30
Fe_2O_3	3·23	Orthoclase	13·34
FeO	5·82	Diopside	4·83
MgO	2·78	Olivine	9·16
CaO	8·09	Magnetite	4·64

A	
Na_2O	3·85
K_2O	2·30
H_2O-	1·76
H_2O+	2·36
CO_2	·71
TiO_2	·41
P_2O_5	·56
NiCoO	03
MnO	·20
SrO	trace
	100·60

B	
Ilmenite	·76
Apatite	1·34
CO_2	·71
Water	4·12
	100·59

Classification II 5. 3. 4.
Andose.

The analysis supports the determination of the plagioclase as labradorite. A further point of interest is that though the rock is evidently fairly rich in the olivine molecule, plagioclase has been the first mineral to crystallise. The rock may be found in all stages of carbonation, the final condition being a yellow-grey rock taken in hand specimen to be a felspathic sandstone. Sections however show the parallel arrangement of the felspars, and that these are scarcely attacked while the glass has been completely decomposed.

Part III. Mineralogical Notes.

In the vughs in the breccia and basalt of Dundas one may find well crystallised *quartz* and *amethyst;* carbonates in the form of *calcite* (of Iceland spar and nail-head types), and small flat rhombohedra of brown *siderite* are not uncommon. In the cracks of the basalt slender prisms of *aragonite* occur. They may be over a centimetre in length and perhaps a couple of millimetres thick. Usually they are twinned. A small crystal was found untwinned and its angles were measured by Mr. L. L. Waterhouse, B.E. His figures proved the crystals to be aragonite, and determined the presence of the following forms (010), (001), (110), (011), (012), (013). From his figures and sketches the clino-

graphic projection (fig. 13) was constructed. In four crystals examined by Mr. G. J. Burrows, B.Sc., and in two examined by myself the presence was noted of acutely tapering domes and pyramids. These faces make exceedingly small angles with the normal prism and pinacoid faces, and are very characteristic of aragonite.

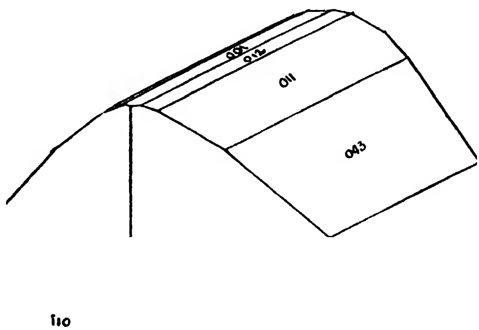

Fig. 13—Clinographic drawing of aragonite crystal.

Pyrites crystal may sometimes be found in the breccia near the basalt neck, they occur in irregular aggregates or in small striated cubes.

Barytes has been recorded from Dundas by Professor David[1] but his specimens were all very small. I was fortunate enough to obtain crystals measuring 10×5×2 mm., and these were measured on the Adelaide University gonometer. The presence of the following forms was deter-

[1] Proc. Roy. Soc. N.S.W., 1893.

mined:—(100), (010), (001), (110), (102), (104); and (111). Figure 14 is a clinographic projection of the crystal.

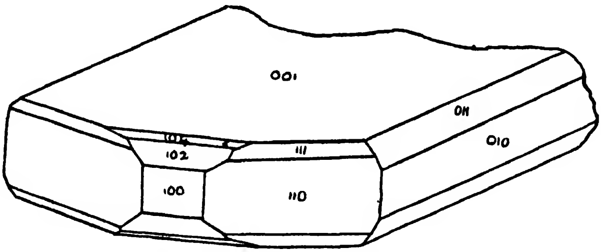

Fig. 14—Clinographic drawing of barytes from Dundas quarry.

Bitumen.—It has been reported to me that bitumen occurs in the Dundas neck, though I have not yet seen it myself. It is, however, frequent in the Hornsby breccia. It forms small patches or filling little cracks perhaps two or three inches in length. It is generally associated with and frequently traversed by little veinlets of calcite. Held in a flame it swells up and froths, but burns away with a smoky flame leaving only a trace of ash. It has doubtless been distilled out of the coal seams below as is the case of the bitumen in the Mittagong syenite.[1]

Part IV. Discussion and Conclusions.

Before attempting to account for the origin and presence of the basic and ultrabasic inclusions in the Dundas and Hornsby necks, it will be well to glance briefly at some other occurrences of the inclusions in New South Wales and elsewhere. Rocks similar to those here described are found in a monchiquite dyke at Kiama[2] and also at Gerringong. These monchiquites are members of a series of dykes which cut through the alkaline Permo Carboniferous volcanic series and intrude also the Triassic Narrabeen series. They are newer than some olivine basalt dykes, and perhaps,

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[1] Mawson, Proc. Linn. Soc. N.S. Wales, p. 582.

[2] C. A. Süssmilch, Proc. Roy. Soc. N.S.W., 1905, p. 65.

though not certainly, newer also than dykes of ophitic dolerite.[1] Lherzolites similar to those here described were found by Dr. Jensen in a monchiquitic lamprophyre dyke in the Nandewar district, which also must be considered post Triassic, probably Tertiary in age, a succeeding phase to a series of eruptions of alkaline rocks.[2] Rocks like the Dundas inclusions are to be found in the neck at Norton's Basin on the Nepean River, and I have seen a micro slide of a dolerite inclusion labelled "Rooty Hill," probably from the dyke there. Gabbro boulders occur in the basalt of Glen Alice (Capertee) and colourless pyroxene crystals (xenocrysts) in the basalts of Mount Wilson, Rooty Hill, Thirlmere and Long Bay. Pyroxene containing picotite occurs in the nepheline basalt of Burragorang and aggregates of olivine, hornblende and picotite in the Bulli basalt dyke.[3] Augite, picrite and eclogite occur in the breccia-filled pipe at Bingera, and are correlated by Mr. Card with above mentioned occurrences.[4] Numerous instances of eclogite occurring in breccia pipes in Southern Monaro are cited by Mr. Pittman.[5] Mr. E. C. Andrews compares the "pebbles" of the Eleanora dyke at Hillgrove, with the inclusions of Dundas, noting the difference in the containing rock.[6]

Through the kindness of Mr. Card, I was enabled to obtain micro slides of an inclusion and its host. The containing rock is a lamprophyre rather than a basic granite. It is camptonitic in character, composed of long brown hornblende prisms and smaller brown hornblende crystals, together with a few larger phenocrysts of nearly colourless

[1] J. B. Jaquet and G. W. Card, Rec. Geol. Sur. N.S.W., Vol. VIII, pt. i, p. 43.

[2] Proc. Linn. Soc. N.S.W., 1907, p. 884.

[3] Rec. Geol. Sur. N.S.W., Vol. VII, pt. iv. [4] *Loc. cit.*, pt. ii, p. 39.

[5] Ann. Rep. Department of Mines, N.S.W., 1908.

[6] Report on the Hillgrove Goldfield, Department of Mines, N.S.W., Mineral Resources No. 8, 1900, p. 25.

augite in a finely crystallised felspathic groundmass. The inclusions are considerably decomposed. They contain pale rhombic and monoclinic pyroxene, intergrown in a curious fashion, and unlike anything noticed in Dundas, together with a considerable amount of the greenish substance, composed of interlacing fibres and irregular areas which has been taken to be talc pseudomorphous after olivine in the Dundas rocks, though the birefringence seems rather low. There is little doubt that the inclusion represents a plutonic ultrabasic rock; but from its apparent association with granitic rocks it does not seem certain that the inclusion is of the same series as the Dundas rocks.

This point must here be left undecided. Nor can we with certainty correlate the Dundas inclusions with the nodules of olivine, pyroxene, and spinel which are abundant, in the basalt flows of New England and the Darling Downs, and which resemble those studied in detail in the basalt of Mount Gambier.[1] These have not been studied at all, in the preparation of this paper, and cannot therefore be dealt with as perhaps they should be in this discussion.

Outside Australia, though nodules of hornblende, pyroxene or olivine, are common enough in basaltic rocks, gabbroid inclusions are singularly uncommon. Lacroix divides inclusions in volcanic rocks into two main groups—enallogenous and homœogenous—(not homogeneous). The former contains those inclusions which in origin and mineralogical composition are in no way related to the including volcanic rocks (as the fragments of sandstone and conglomerate in the Dundas neck); the latter group comprises those inclusions which in mineralogical composition and origin exhibit a more or less marked analogy with the enclosing rock.[2] But it is in just such rocks as are here described, that he

[1] E. R. Stanley, Trans. and Proc. Roy. Soc. South Austr, 1909, p. 66.
[2] Les enclaves des Roches Volcaniques, 1893, p. 8 and 9.

finds difficulty in applying this distinction. He doubtfully classes as enallogenous gabbros and norites in basaltic tuff and basalt in various parts of France, believing them to be fragments of older formations, on account of their passage into rocks containing garnet, quartz or biotite, and presumably of ancient origin.[1] At the same time he considers certain augite-plagioclase inclusions in basalt at Coirons to be homœogenous, admitting the uncertainty of the former classification.[2] In later works[3] Lacroix developes a subdivision of the homœogenous group into the following divisions:—the allomorphous, fragments of masses already consolidated at depth; plesiomorphous, segregations formed in the magma which have not had a separate existence as geological units; the polygenous and pneumatogenous divisions do not here concern us. The allomorphous and plesiomorphous inclusions are further subdivided into homologous, formed by the mean type of the enclosing magma, and the antilogous formed by basic differentiation or original heterogeneity.[4]

Applying all this to our present problem:—if we were to consider the Dundas inclusions as enallogenous we would require to assume the existence of a batholith of basic and ultrabasic rocks underlying nearly the whole of the eastern portion of New South Wales. So large a batholith of rocks of this basicity is almost without precedent. Further, though underlying a district of very diverse geological character, it never appears at the surface, unless we take as portions of it the Carboniferous (?) norites of Kiandra, described by Mr. E. C. Andrews[5] or the gabbro of Adelong

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[1] *Op. cit.*, pp. 129, 130. [2] *Op. cit.*, pp. 473, 474.

[3] Sur deux nouveaux groupes d'enclaves des roches eruptives, Bull. Soc. fr. Min., XXIV, 1901, pp. 488.

[4] Note.—For this summary of Lacroix' views I am indebted to the paper prepared by Mr. J. A. Thomson, on the Inclusions of the Volcanic Rocks of the Ross Archipelago, to appear in the Geological Memoirs of the British Antarctic Expedition, 1907 - 1909.

[5] Department of Mines N.S.W., Mineral Resources, No. 10, 1901, p. 17.

(noted by Professor David). The ultra basic rocks of the Gundagai district[1] and those of the belt stretching from Nundle to Bingara[2] do not appear to be associated with such a batholith at all. From their great length and small width, and particularly from their parallelism to the strike of the country rock, they seem rather magnificent examples of sills of sima rocks intruded along fold lines, as described by Suess.[3] Moreover, all of these instances are three hundred miles or more from Sydney. As a final condition the hypothetical batholith must have a highly differentiated marginal facies at almost every centre of late volcanic activity, to account for the variety of inclusions where these are present in Tertiary basalt, or the monchiquites. These necessary assumptions place the existence of such a batholith almost beyond the bounds of possibility. If, on the other hand, we consider the great mass as broken up into small highly differentiated bodies, their non-appearance at the surface and deep seated occurrence in association with centres of eruption suggest their genetic relationship to the volcanic eruptive products. Further we may note that none of the igneous rocks present as inclusions are such as might not have differentiated out from a magma of the composition of their host.

The Sydney basalts and those of the South Coast are sometimes normally alkali-calcic, sometimes nepheline-bearing. They seem to be the final products of a series of eruptions from a magma which in its earlier stages was distinctly alkaline, but succeeding eruptions distinctly less so.[4] Reflecting this alkalinity, we have among the series of plutonic inclusions normally alkali-calcic, as here described, a semi-alkaline rock, the essexite of Hornsby.

[1] J. E. Carne, Ann. Rep. Dept. Mines, 1892 and 1895, also P. T. Hammond, Rec. Geol. N.S.W.
[2] W. A. Anderson, Ann. Rep. Dept. Mines, N.S.W., 1888, p. 179.
[3] The Face of the Earth, Sollas' translation, Vol. IV, p. 564, 1909
[4] J. B. Jaquet, and G. W. Card, *op. cit. supra* p. 66.

Essexite, it may be here noted, occurs in sills at Jellore, intruding Permo-Carboniferous and Triassic rocks, and associated with picrite, corresponding apparently to the gabbro poor in felspar of this paper.[1] Essexitic rocks also occur in the igneous series at the Nandewar Mountains.[2] The dolerite inclusions in the basalt might easily have consolidated in dykes from such a magma as now forms the basalt. Further, the various types of alteration which have modified the rocks of the plutonic inclusions seem all such as might have taken place while the rocks were in their present position. Pressure has played an almost negligible part in their metamorphism, hydration, carbonation and silicification, a very important one. Flaser-and-saussurite-gabbros or schistose serpentines, such as one might expect on the margin of ancient basic batholiths have not been found in the volcanic necks and dykes. The trachytic and hyalopilitic basalts may be fragments from flows which are extensions of the Cambewarra volcanic series, which is an earlier expression of the magma that has given rise to the Sydney basalts.[3]

It therefore seems most satisfactory to regard the inclusions of igneous rocks in the volcanic necks as homœogenous. They seem in every way fragments of rock masses not mere segregations. They, therefore, are to be classed in the allomorphous group. The plutonic members of the series of inclusions probably were part of a differentiated crust to the magma reservoir from which the basalt has arisen. In mineralogical composition the gabbros and norites are homologous with the basalt, the peridotites antilogous. As the anorthosites and pyroxenites may be considered as derived from the gabbros by splitting, they may be classed as antilogous. The doleritic and basaltic inclusions are distinctly homologous.

[1] Taylor and Mawson, Proc. Roy. Soc N.S.W, 1903, p. 324.
[2] H. I. Jensen, Proc, Linn. Soc. N.S.W., 1907. p. 883.
[3] Jaquet and Card, *op. cit.*

The "olivine nodules" of the basalt flows and the single crystals or segregations of hornblende or pyroxene are not under review in this paper, though it may be remarked here that Lacroix[1] would consider the former of these as allomorphous antilogous, the latter plesiomorphous antilogous inclusions. These conclusions are in accordance with the results obtained by Mr. J. A. Thomson, B.Sc., from his study of a somewhat similar series of inclusions in the rocks of the Ross Archipelago in the Antarctic.[2]

SUMMARY.

At Hornsby and at Dundas volcanic necks occur. In both of these during the first epoch of activity the vent was filled with a volcanic breccia. In this were included fragments of the sedimentary formations passed through the Narrabeen and Hawkesbury sandstones, a little bitumen distilled out of the coal measures now three thousand feet below the surface, plentiful fragments of a trachytic or hyalopilitic basalt and of basic or ultrabasic plutonic rocks including at Hornsby essexite.

At Dundas this first volcanic activity was followed by the intrusion into breccia of olivine basalt, which may have formed a flow on the surface, but now is seen only as a plug with dykes ramifying through the breccia. In this are contained to a fuller extent and in better preservation, the same series of basic and ultrabasic inclusions. The series contains anorthosites gabbros, hypersthene gabbros, olivine gabbros, norites, diallagites, harzburgites, lherzolites, dunites, and the less plutonic types, gabbro porphyry and dolerite. These, together with the essexite, are considered to be fragments of a highly differentiated intratelluric crystallisation of the same magma as later gave rise to the

[1] Les Enclaves des Roches Volcaniques, p. 490, and statements there made as referred to his later subdivisions of the classification.

[2] *Op. cit. supra.*

including olivine basalt. They are therefore cognate inclusions in Harker's sense of the term, homœogenous in Lacroix' classification. They belong to homologous and antilogous groups of the allomorphous division of such inclusions. They present many features of exceptional interest, both in their mineralogical composition and manner of alteration. One rock type containing granophyric intergrowths of pleonaste and pyroxene and free from magnetite, though common at Dundas, does not appear to have been found in any other part of the world. It is well worthy of further investigation. Well crystallised quartz, amethyst, pyrites, calcite, siderite, aragonite and barytes may also be found at Dundas.

These notes cannot be considered exhaustive. Each visit to the Dundas quarry yielded new material showing fresh features, and as the work of excavation progresses much more may be revealed.

Acknowledgements.

My thanks are primarily due to Mr. T. G. Taylor, who on his departure for England, handed over to me his notes and collections from the Dundas quarry, and to Mr. C. A. Süssmilch who withdrew in my favour from the work on Hornsby. To Professor David I am ever indebted for his kindly interest in my work and valuable information and advice. Dr. Woolnough has given me useful advice in the petrology, Mr. Dun help in obtaining reference to some of the literature, Mr. Card in giving much information with regard to the less known occurrence of inclusions in New South Wales. Messrs. C. A. Süssmilch, R. E. Priestly, J. L. Froggatt and H. G. Gooch, have allowed me to examine their slides of Dundas rocks, and I have also availed myself of the collections of the Sydney and Adelaide Universities and the Sydney Technical College. I am especially indebted to Mr. J. Allen Thomson, who has given me the benefit of his

extensive studies on the subject of inclusions and assistance in the difficult determination of some decomposition products. Mr. L. L. Waterhouse has allowed me to use his measurements of the aragonite crystals. To all these gentlemen I tender my hearty thanks.

Description of Plate XXXIV.—Photomicrographs.

Fig. 1. Quartz, pseudomorphous after serpentine, in quartz-carbonate rock derived from dunite. Polarised light. × 25.

„ 2. Pseudoporphyritic structure in dunite, probably due to differential granulation. Polarised light. × 18.

„ 3. Intergrowth of pleonaste and augite in gabbro porphyry. Ordinary light. × 18.

„ 4. Serpentine after dunite. Polarised light. × 25.

„ 5. Junction of gabbro and basalt, showing differential absorption of the minerals of the gabbro by the basalt magma. Ordinary light. × 8.

„ 6. Hyalopilitic basalt in the Hornsby volcanic breccia. Ordinary light. × 32.

(Photomicrographs by H. G. Gooch.)

NOTE ON THE OCCURRENCE OF *EURYDESMA* IN THE UPPER MARINE (PERMO-CARBONIFEROUS) OF NEW SOUTH WALES.

By W. G. WOOLNOUGH, D.Sc., F.G.S.,
Assistant Lecturer in Mineralogy and Petrology and Demonstrator in Geology, University of Sydney.

[With Plate XXXV.]

[*Read before the Royal Society of N. S. Wales, November 2, 1910.*]

UNTIL quite recently *Eurydesma* was looked upon by the geologists of New South Wales as characteristic of the Lower Marine Beds; but in 1905 Süssmilch[1] discovered it in rocks near Belford whose age is considered to be Upper Marine. An interesting section was examined recently by the author in Wattle Ponds Creek (a tributary of the Hunter River) above the point where it crosses the Dyrring Road, three and a half miles in a straight line north-east of Singleton.

An exposure of the Bolwarra Conglomerate is met with in portion 34, Parish of Darlington, giving rise to the bare stony outcrop so characteristic of this rock. The dip is N. 60° W. at 10°. Following the creek for a distance of about 1,500 yards, we pass over sandy mudstones with abundant glacial erratics, many of them decidedly facetted, and an occasional one obscurely striated. The dip of this formation (Branxton Beds) is not quite constant, but varies from the value given above for the Bolwarra Conglomerate to N. 50° W. at 8°. This indicates a thickness of some 694 feet for this part of the glacial beds.

Next comes a zone containing very large erratics; one, of Silurian limestone (see below), has a length of nearly

[1] Proc. Linn. Soc. N. S. Wales, 1906, XXXI, pt. i, p. 175.

four feet, while another, of Devonian quartzite, is exposed for a length of over four feet six inches. The zone of large erratics has a thickness of approximately 100 feet. The mudstone containing the erratics is simply crowded with *Strophalosia* and other fossils (see below). It is at the base of this zone that large and beautifully preserved specimens of *Eurydesma* occur. As determined by Mr. Dun, the species is *E. hobartense* and not *E. cordatum*, which is the one so characteristic of the Lower Marine Beds.

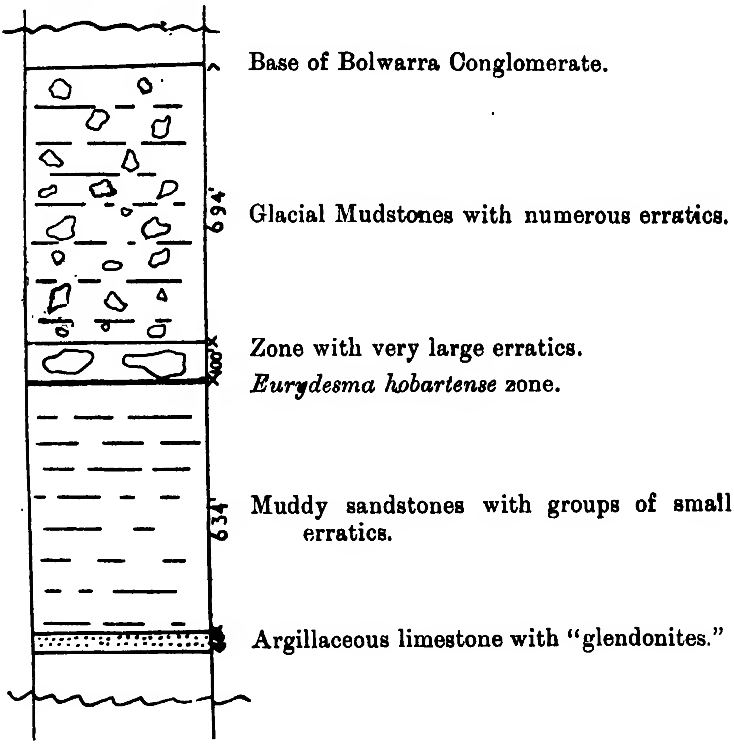
Below the *Eurydesma* zone exposures are not very good, and time did not permit of a detailed examination being made. The rocks are sandy mudstones with little groups of small erratics, very strongly recalling the beds associated with "glendonite" at Jervis Bay.[1] The dip gradually swings round until, just above the road-bridge over Wattle Ponds Creek, it is N. 50° E. at 10°. The creek was not followed below the bridge, but at "The Retreat," half a mile distant down stream the dip is N. 20° E. at 3°. I estimate that the beds between the *Eurydesma* zone and the road are about 450 feet in thickness, and hence to "The Retreat" about another 185 feet. The rock at "The Retreat" is a massive sandstone with very few erratics. Below the *Eurydesma* zone the section is singularly barren in fossils.

Along the road towards Singleton, close to the point where it crosses the southern branch of Wattle Ponds Creek, is a thin band of flaggy argillaceous limestone of light buff colour, containing small "glendonites" of the composite type characteristic of the upper horizon of Jervis Bay. From the arrangement of the beds this horizon appears to lie slightly below the sandstone of "The Retreat"; but in absence of definite measurements it is impossible to estimate

[1] Records Geol. Surv. N,S. Wales, 1905, Vol. VIII, p. ii, p. 168.

its position accurately. I anticipate that it will be found some 40 feet to 50 feet below the shelf of sandstone above mentioned.

Summary.—The geological section of the Upper Marine Permo-Carboniferous Beds in Wattle Ponds Creek, between Portion 34, Parish of Darlington, County of Durham, and "The Retreat," at the junction of the main creek and a tributary in the temporary common, is as represented in the figure below.



The most noteworthy features of the section are:—

1. A zone of very large glacial erratics, some 694 feet below the base of the Bolwarra conglomerate;
2. A zone with well preserved *Eurydesma hobartense*, about 794 feet below the same datum; and

3. A zone of glendonite pseudomorphs at 1,480 feet (approximately) below the same point.

I am indebted to Mr. W. S. Dun, Government Palæontologist and Lecturer in Palæontology at the University of Sydney, for the following list of fossils collected by me during a hurried visit to the section described above. The list is far from complete, fossils being very abundant and well preserved in the belt immediately overlying the *Eurydesma* zone.

In the Upper Marine Glacial Sandstones:—*Strophalosia Clarkei; Eurydesma hobartense*; *Deltopecten subquinquelineatus; Productus brachythœrus; Fenestella (?) fossula; Chœnomya Etheridgei*; *Martiniopsis subradiata* (var.); *Mœonia carinata* (var.). In a large erratic of Silurian limestone:—*Favosites gothlandica* traces of a Stromatoporoid.

EXPLANATION OF PLATE XXXV.

Figs. 1 and 2 Photographs of a block of glacial sandstone containing well preserved *Eurydesma hobartense.* Fig. 1 × ⅔ about; Fig. 2 × ½.

NOTES ON THE GEOLOGY OF KING ISLAND, BASS STRAITS.

By F. Debenham, B.A., Deas-Thomson Scholar in Geology, University of Sydney.

[Communicated by W. G. Woolnough, D.Sc., F.G.S.]

[*Read before the Royal Society of N. S. Wales, November 2, 1910.*]

Contents.

Introduction.—King Island is situated at the western end of Bass Strait, and is midway between the mainland and Tasmania, its distance from either being about 55 miles. The island is roughly trapezoidal in outline with its longer axis in a meridional direction, its extreme length is 40 miles, extreme breadth 16 miles, and area approximately 400 square miles. It is therefore, with the exception of Flinders Island, the largest island in the Straits, and a rough idea of its size may be gathered from the fact that, looking at Bass Strait from due west, King Island blocks up rather more than a quarter of its western entrance.

In view of certain tectonic relationships to be considered later, it is necessary to draw attention to the fact that the island is to the north-west of Tasmania, and that if we produce the line of the west coast of Tasmania it will pass through King Island and reach the Victorian coast a little to the west of Cape Otway. The island possesses a remarkably equable climate, but it is subject to heavy westerly

winds. The rainfall is constant, but not so profuse as on the west coast of Tasmania, one figure for the annual rainfall being 44 inches.

The island is a dependency of the Government of Tasmania, and, although until recently it was the home of only a few marsupial hunters, it is now regarded as a valuable asset, its rapid advance being chiefly due to the determined struggle of the settlers against certain natural disabilities, cattle disease being the chief. The population is now over 600, the staple industries being the fattening of cattle and dairying.

Previous Literature.—Very little reference to King Island is to be found in scientific literature. A systematic bibliography is not attempted here, but, so far as the writer knows, the only paper dealing directly with the geology of the island is a recent one on the sub-fossil bones found there, by Professor Baldwin Spencer and Mr. Kershaw. References to the geology of the island are made by Mr. R. M. Johnston and others in general papers on Tasmania and Bass Straits, but apparently no detailed geological examination has yet been made.

General information as to Bass Straits will be found in R. M. Johnston, Syst. Acct. Geology, Tasmania, 1888; A. W. Howitt, Rept. Austr. Assoc. Adv. Science, VII, 1898, pp. 723—758; W. Baldwin Spencer and J. A. Kershaw, Mem. Nat. Museum, Melbourne, No. 3, 1910.

Physiography.—The physiography of King Island is sufficiently remarkable to call for detailed notice. When we remember that the Cape Otway Ranges rise to over 1,000 feet, and the north-western Tasmanian ranges higher still, and further, that the islands at the eastern end of Bass Strait are of marked relief (Cape Barren Island, 2,500 feet) it is somewhat surprising to find that King Island possesses no hill higher than 600 feet, and nothing in the

nature of a hill system. For the purposes of description we may divide the island roughly into two areas:—

(i.) The Coastal Strip—narrow and low on the eastern side, broader and covered with high sandhills on the western side, and narrowed almost to extinction in the south-eastern corner where the plateau extends right to the coast.

(ii.) The Plateau Area—which occupies the inland portions of the island, and from an average height of 200 feet in the northern and central divisions rises to 500 feet in the south and east, and presents a bluff aspect to the sea.

The general low relief is responsible for the monotonous appearance of the island as viewed from the sea, so different to the bold outlines of the Furneaux Group, or even of the Hunter Group only 50 miles to the south-east. It has the effect also of giving King Island a unique if somewhat uninteresting type of scenery consisting of stretches of flat country unrelieved by anything more imposing than occasional belts of heavy timber. In the south-eastern portion however, we do meet with a miniature of the steep fern-gullies, scrub-clad ravines, and general rugged contours so typical of West Tasmanian scenery.

Owing to the constant rainfall, a number of small streams make their way from the plateau area to the sea on all sides. Those in the northern half of the island are short and sluggish, and affect the contour of the country but little. Those in the southern half, however, are more interesting as giving evidence of importance as to the stage of peneplanation reached. Of these the Ettrick, the Grassy and the Fraser Rivers are the most typical and the courses of each show all the phenomena of a youthful stage of degradation.

For watersheds of such low relief their gradients are fairly steep, and their courses comparatively straight. All three, but more especially the Grassy River, have carved

out V-shaped valleys, and the south-eastern corner of the island is a maze of small but steep hills and valleys. The southern half, then, of the island is typically a dissected plateau of a youthful type. That the northern half is not so is to be explained by its excessively low relief and its continuous fringe of sand-dunes rather than by a separation in age of elevation. On the western side the presence of the fringe of high sand dunes has an important influence on the drainage and consequent denudation of the island. The dune area is considerably higher than the adjoining inland country. The drainage is therefore temporarily stopped at the junction, and this gives rise to numerous bogs, marshes and shallow lagoons which are relieved by slow soakage through the dune sand to the coast. The larger streams have been able to keep open an outlet which, as in the case of the Ettrick River, takes the form of a gorge bordered on both sides by dunes up to 250 feet in height. This stagnation and the general low relief have combined to cause a feature which is highly characteristic of the island.

Except in the few localities where outcrops of rock are found, the surface of the island is covered to a depth of several feet with a loose sandy soil, which in the low lying areas is replaced by peat. The sand is not worn to any appreciable extent, and is formed of grains of quartz and felspar, and is everywhere mixed with much decayed organic matter. The presence of angular fragments of the slates and quartzites, scattered through the soil and subsoil, confirms the idea that it is merely the disintegrated original rock and is not transported detritus. Occasional patches of yellowish stiffer soils seem to mark the position of dyke rocks, as was definitely proved in one case. It is, therefore, only along the coast that extensive outcrops of rocks occur.

A study of the submarine contour lines in the western part of Bass Straits shows that the gradient is decidedly

steep on the western side of King Island, but very gentle on the eastern side. This lends support to the idea that King Island should be regarded as a 'horst' standing out above the great Bass Strait senkungsfeld, the steep gradient of the western coast line marking the fault lines, which would therefore run in a meridional direction. Mr. T. Griffith Taylor has pointed out the importance of this fact in the correlation of the earth movements here with those along the eastern coast of New South Wales where the faulting is meridional.

Geology—The Sedimentary Rocks.—The sedimentary rocks met with on the island fall into the three divisions:—Recent, Tertiary and Early Palæozoic.

Recent—

(i.) Sand dunes on the western side and the associated arenaceous limestones.

(ii.) The peat beds of the lagoon areas.

(iii.) The "Black Sand" of the Fraser River.

(i.) The sand dunes occur in a coastal strip, averaging one and a half miles in width, extending the whole length of the island on the western side. Presenting as they do all the characters of typical dunes, they have obviously been formed by the prevalent west and south-west winds. The question as to whence the sand came is not so obvious. Careful search was made along the coast for raised beaches or other evidence of recent uplift, but without success. But from their discovery in connection with dunes on the other islands of Bass Straits and on the mainland of Victoria we may perhaps assume that King Island shared in the elevation of 40 – 50 feet, which seems to have affected Bass Strait in Post-Tertiary times.

The dunes range up to 250 feet in height, and are almost everywhere covered with herbage. In places heavy timber is growing on the sandhills, a fact which points to their

stationary character as well as to their comparative fertility. The sand of the dunes is highly calcareous and fragments of shells form a large percentage of it. An analysis of a typical sample gave the following figures:—

Organic matter	11·59
Insoluble residue	58·58
Al_2O_3 and Fe_2O_3	2·69
SO_3	·35
P_2O_5	·403
MgO	7·10
CaO	14·80
Undetermined	4·48
	100·00

The dune limestone, which is the consolidated dune sand, is in many places of considerable thickness and hardness. It is horizontally bedded, and only outcrops on the flanks of the steeper dunes. In texture it is uniformly coarse grained, the fragments being more or less closely cemented with secondary calcite. The subject of the sand dunes would not be complete without a reference to what is known locally as the "Sand-Blow" on Stokes' Point, the extreme southern projection of the island. This is a dune area of large dimensions, which in recent years has become denuded of vegetation and is now in the usual shifting state of sand hills. The wind has exposed many interesting sub-fossil remains, notably those of an emu and a wombat, types of fauna recently extinct on the island. The bones are not very well preserved, but they have been well exploited by Mr. James Bowling of Surprise Bay, and have been examined and described by Professor Baldwin Spencer, Mr. Kershaw and others. The shifting sand has also laid bare large numbers of calcified root casts and even complete butts of trees, a fact which supports the theory that the dunes go

through cycles of alternate denudation and shifting, alternated with periods of stability and vegetation.

The Peat Beds.—These are interesting, chiefly because of their wide extent and their depth. They are formed chiefly in and close to the sand dune country, but may be met with in almost any part of the island, being a product of the general stagnation of water circulation. They contain a small percentage of drift sand, and for a depth of at least eight feet are quite soft and unconsolidated. The bracken fern which is very abundant on the island seems to have provided most of the material for the peat, but numerous marsh weeds and rushes grow luxuriantly upon them and help to retard what little surface drainage there may be.

The Monazite Sand of Fraser River.—On the east coast at the mouth of the Fraser River there is a peculiar deposit of black sand, containing monazite and tin. From a hurried survey the deposit seems to be about a mile in length, and from 50 – 100 yards in width. It is adjacent to and parallel with the beach. There seems no evidence to show that it is a fluviatile deposit, and the sand at present brought down by the Fraser River is quite distinct. The fact that it is in a narrow belt parallel to the present coast line and but thinly covered with sand leads one to suppose that it is a littoral deposit, the material being provided by a pegmatite vein close inshore, and finally sharing in the supposed recent elevation. The sand is black and heavy and would easily be concentrated by wave action, it contains a few pebbles chiefly of quartz, much waterworn. The monazite is present as very fine sand and an attempt has been made to recover it on a commercial scale, but without marked success. Its content of thorium is sufficient to make the concentrates appreciably radioactive, but no other measurements have been make by the writer.

Tertiary Limestone.—Of this only one small outcrop was met with, but from its thickness it is probable that there is a good deal hidden under the loose sand drift in the south of the island. It occurs on the bank of a creek which runs into the Seal River, at a spot about one mile due east of the south-east corner of E. Mason's Block, but the outcrop is so small that it is very easily overlooked. A thickness of about twenty feet only is visible, dipping slightly to the west, and the length of the outcrop is only about forty feet, the rest being hidden under sand and detritus. The upper strata are of fine broken shell sand, very hard and firmly cemented, the lower of coarse fragmental material with complete shells and pebbles of schists and quartzites, from which we may infer that the area was undergoing subsidence, the coarser material with complete shells representing the deposit close inshore, the finer material that when it was farther out. Mr. W. S. Dun has very kindly examined the specimens collected by me, and I quote his notes on them in full:—

"Mr. Hedley has also seen the specimens and has compared the Mollusca with species of the recent marine fauna of the Bassian subregion and the following conclusions have been arrived at. Several well marked forms occur, more especially a *Pecten* and a *Lima*.

"1. *Pecten.*—The *Pecten* is apparently very closely related to *P. antiaustralis*, Tate, which would fall in the group typified by the recent *P. asperrimus*—in fact it is very close indeed to some deep water types of that species which were dredged by Messrs. Hedley and May. *P. antiaustralis* has been collected at Muddy Creek, Aldinga (Miocene ?) and from the Dry Creek and Croydon Bores of South Australia, considered by Tate as Pliocene. *P. asperrimus* has also been found in the Croydon Bore.

"2. *Lima.*—A *Lima* cf. *Bassi*, T.-Woods, also occurs. The distribution of this species covers a great geological range.

being found in the Eocene (Tate and Dennant) of South Australia, Victoria, and Tasmania (Table Cape); and in the Miocene (?) of South Yarra and Moonee Ponds, and the Pliocene of South Australia (Dry Creek Bore). From this it will be seen that this type of *Lima* is not of great stratigraphic value in the absence of a series of short-lived species.

"3. Associated with these are *Hipponyx* cf. *australis*, Q. and G., *Turritella* (sp. ind.), ?*Hemithyris* (somewhat like *H. colourus*, Hedley), shell debris, Polyzoa (*Retepora* etc.)

"The general appearance of the shell limestone is rather that of a rock resulting from sedimentation at some distance from land than of a shore deposit. Though there is nothing definitive in the small collection we are inclined to group the beds with those at Cape Finn and Table Cape, which it has been the custom to regard as Eocene, as understood by Tate, though it is probable that renewed examination in the light of greater knowledge may tend to place them higher in the Tertiary."

Palaeozoic.—Early Palaeozoic rocks are extensively developed on the island, and may be said to form the plateau of which the granite massifs are the buttresses. Since they are apparently unfossiliferous and their age has so far been determined on lithological evidence only, it becomes important to study their petrological characters rather fully, to afford data for comparison with other localities. The rocks developed include quartzites, slates and phyllites, mica- and garnet-schists, actinolite-schists, granulites, porphyroids, and conglomerates. They are a much altered series of rocks, and the metamorphism they have undergone has rendered it difficult to trace their true origin in many cases. They are on the whole very regularly bedded and in places even the smallest laminæ are clearly marked and can be traced for considerable distances. In the neighbourhood of some of the intrusives, however, and

especially at Stokes Point they are highly schistose and contorted.

The beds on the western side of the island dip at high angles (50° – 70°) to the west, and on the east at moderate angles (30° – 40°) to the east, so that the island appears to consist of a ge-anticline of these beds. Such an assumption is only provisional in view of the absence of any positive measurements of dip and strike in the interior of the island. The strike of the beds wherever measured was constant at from 5° – 20° east of north (magnetic) with an average of 12°. The geotectonic line upon which the island lies, therefore, has a general trend of north 20° east. This is somewhat remarkable, for although it agrees with the direction of the Cambrian and Pre-Cambrian axes north of Adelaide, it is at marked variance with the same axes in Tasmania and Victoria, which, as forming the western limb of the great East Australian tectonic V, trend to the west of north. Certainly the strike thus measured only extends some thirty miles, but it is so uniform that there can be no doubt of its continuity within reasonable distance of the island.

Another peculiar fact about the series is its remarkable thickness. On the meagre measurements at our disposal it is impossible to give any figure with certainty, but it seems probable that one is understating the thickness at 20,000 feet. It is quite possible that more than one system is here included, they being in approximate conformity. But, except that towards the crest of the anticline, *e.g.*, at Stokes' Point, they are more schistose and possibly dipping at a slighter angle, there is little to separate the beds.

Only at one locality was a series of consecutive measurements obtained. This was in a traverse of two and a half miles up the gorge of the Ettrick River, the dip varying

from 55° – 60°, strike from north 10° east to north 15° east. There was no recognisable change in the lithology of the beds, the dominant type was a quartzite or granulite, in beds up to 200 feet thick, interbedded with slates, phyllites, mica- and garnet-schists. Probably a more detailed survey will establish the existence of many definite horizons.

The Eruptive Rocks.—*The Granites.*—As stated above the island is, so to speak, buttressed by large batholiths of granite. On the western coast at least six separate masses were examined, and one on the south-east coast at the mouth of the Grassy River. All these have intruded the Palaeozoic rocks, but no evidence as to their age is forthcoming. They resemble the Tasmanian Devonian granites strongly, and we may provisionally assign that age to them. They are certainly old granites and have been subjected to some of the dynamic metamorphism which has affected the whole region, for not only are the felspars much altered and saussuritized, but the quartz gives a wavy extinction, and there is a large development of sericite. The west coast granites are all grey biotite-granites, with accessory muscovite. The granite at the mouth of the Grassy River is a light red rock with abundant pink orthoclase, biotite not so prominent.

In all the junctions examined the granites appear to have intruded the slates without much mutual alteration. In one case the granite has spread into the bedding planes of the slates for quite a long distance, so that we get alternate laminae of slate and granite. Large pegmatite veins extend into the slates from the granite masses, one of which was measured as extending to a distance of one and a quarter miles from the surface outcrop of the parent mass. The pegmatites are in places very coarse, masses of pure felspar as large as eighteen inches through being measured. The constituent minerals are chiefly quartz and orthoclase, with

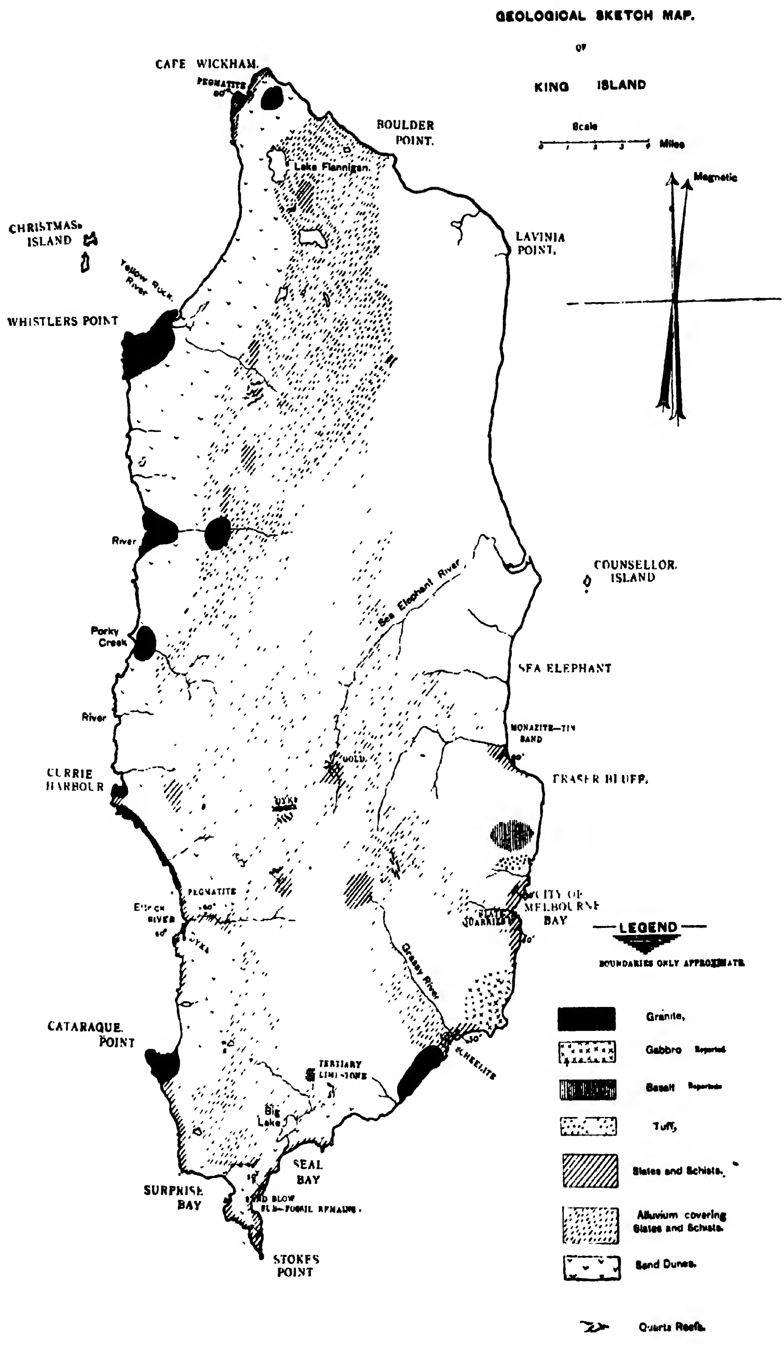
varying amounts of muscovite and tourmaline, the latter both massive and columnar.

Dyke Rocks.—Only two typical dyke-masses were met with, but from the abundance of quartz veins through the slates, clay, ironstones, etc., it seems likely that many are hidden by the depth of alluvial which hides true outcrops all over the island. Of these dykes, one at the mouth of the Ettrick River is composed of a coarse grained dolerite with porphyritic felspars. Its augite is almost completely uralitized, and its abundant ilmenite is largely altered to leucoxene. The dyke is about twenty feet broad and runs in a direction parallel to the strike of the slates, but there is evidence to show that it is not a sill.

The second intrusive rock is met with on the road to the Sea Elephant Gold Mine, a spot about four miles from Currie Harbour. It is in thick scrub and was found entirely by accident, but its outcrop is very well defined for about fifty yards as a bank of sandy soil lightly covering the rock. The surrounding country is widely traversed by veins of smoky quartz and the dyke itself is fringed by the same. The rock itself is a basalt containing abundant augite, ophitic to the subordinate felspar and accessory minerals.

Of other igneous rocks on the island two may be mentioned as being reported, but they were not visited by the writer. Of these the gabbro reported from Bold Head seems very probably correct, judging from a chip shown to the writer. The basalt shown on the map south of the Fraser River is on slender evidence only, but is interesting in connection with the discovery of a basic tuff at the City of Melbourne Bay.

The field relationships of this tuff were unfortunately hidden by sand, but inclusions of the palaeozoic rocks are found in it. It is a hard reddish rock, and under the microscope is not very satisfactory, as it is very decomposed.


GEOLOGICAL SKETCH MAP.
OF
KING ISLAND
Scale
Miles
Magnetic
CAPE WICKHAM.
PEGMATITE
BOULDER POINT.
Lake Flannigan.
CHRISTMAS ISLAND
LAVINIA POINT.
Yellow Rock River
WHISTLERS POINT
River
COUNSELLOR ISLAND
Sea Elephant River
Porky Creek
SEA ELEPHANT
River
MONAZITE—TIN SAND
CURRIE HARBOUR
FRASER BLUFF.
GOLD
DYKE
PEGMATITE
CITY OF MELBOURNE BAY
RIVER
SLATE QUARRIES
LEGEND
BOUNDARIES ONLY APPROXIMATE.
Grassy River
CATARAQUE POINT
SCHEELITE
TERTIARY LIMESTONE
Big Lake
SEAL BAY
SURPRISE BAY
SAND BLOW
SUB-FOSSIL REMAINS.
STOKES POINT
Granite,
Gabbro Reported.
Basalt Reported.
Tuff,
Slates and Schists.
Alluvium covering Slates and Schists.
Sand Dunes.
Quartz Reefs.

The basis of the rock is a brownish palagonite-like network enclosing small fragments of stony material and a large number of replacements by calcite of some minerals or inclusions. Other secondary minerals, such as delessite are found in the cavities. It is possible that this tuff may be connected with volcanic rock to the north, and both with the Tertiary eruptives of western Victoria, but the data at hand are too meagre to allow further hypothesis.

Economic aspects of the Geology.—In view of the prospect of a systematic examination into the mineral resources of the island being made before long, and consequent upon the superficial attention paid by the writer to this branch of the subject this note will necessarily be brief.

Gold.—The quartzite-slate series of beds which forms the bulk of the island is in many places intersected by quartz reefs. These, for the most part seem to be barren of minerals, but the occurrence of a mineralized reef at one place lends colour to the belief that further prospecting should bring others to light. This is at a place on the Sea Elephant River which was prospected by a company some two years ago, but which was abandoned, we believe, largely because of the heavy preliminary expenditure of capital upon road making, trench-prospecting, etc. Reliable data as to the assays were not obtained. The reef runs through the slates, which here dip gently to the west, and in places is eighteen inches in width. It contains much sulphide ore and small samples are said to have assayed well for gold.

Scheelite.—At the mouth of the Grassy River at the junction of a granite mass with the palaeozoic rock a deposit of scheelite was worked for some time. The venture apparently lapsed for want of capital. The mine itself was not visited, but in a number of small reefs nearer to the granite abundant indications of copper in small quan-

tities were found. The district from a hurried examination seems to deserve further prospecting, but the paucity of outcrop of the rocks themselves would render it expensive.

Monazite and Tin.—At the mouth of the Fraser River a deposit known as the "Black Sand," was for some time treated with an expensive plant for its content of monazite and tin. The monazite was separated without great difficulty, but its low percentage of thorium forbade its ready sale, and the tin concentrates did not pay for the cost of working. Cheaper methods of separation may yet enable the deposit to be worked, but the chief importance in its existence is the probability that elsewhere in the island there may be tin connected especially with the pegmatites which accompany the acid eruptive rocks.

The Building Slates.—At the City of Melbourne Bay on the east coast an attempt is now being made to prove the slates for building and roofing purposes. At the time of our visit (Feb. 1910) a tunnel had been driven into the hill, and slate of moderate quality, suitable for flagstones had already been reached at a distance of 70 feet. These slates should perhaps be called shales in obedience to a distinction made by some authors, since the planes of fissility are those of the bedding and have not been superinduced by subsequent transverse pressure. The slates are of two colours on the surface, a handsome dark red and a greyish-green.

Porcelain materials.—The possibility of the coarse pegmatite veins described above being of economic importance as a source of felspar for porcelain making may be mentioned.

Petrological Notes.—The following are descriptions of a few of the rock types met with. The most interesting are a series of biotite granulites, which in hand specimens look

like massive quartzites. They form the majority of the types, in the Palaeozoic beds and their petrogenesis is exceedingly difficult to follow. In some cases they appear to be the products of metasomatic replacement of sedimentaries, in others they may be much metamorphosed eruptives, but the distinction is hard to define.

1. *Actinolitic Conglomerate Schist*, Stokes' Point.

Macroscopic.—In hand specimens a handsome rock, the radiating aggregates of actinolite standing out on a light grey background. The sericite can be made out with a pocket lens. The rock is decidedly schistose and the included pebbles have been drawn out.

Microscopic.—Actinolite, quartz, magnetite, sericite. The actinolite is in porphyroblastic aggregates, feathery and curviform, also in shreds in the groundmass. The quartz forms the matrix in a very fine-grained mosaic, the granules separated from each other by shreds of sericite and actinolite. The magnetite in fine grains and aggregates throughout the section.

2. *Sericite-quartzite*, Ettrick River.

Macroscopic.—A massive grey rock of even fine grain, a little sericite can be distinguished with a pocket lens.

Microscopic.—Quartz, plagioclase, sericite, biotite, zircon. The quartz forms the bulk of the groundmass in small clear grains interpenetrating the felspar, which is undecomposed but crowded with inclusions, a few grains show multiple twinning. Biotite in shreds throughout the slide much altered to chloritic material, in places intergrown with the sericite. Zircon in numerous small irregular grains.

3. *Dolerite Dyke* at mouth of Ettrick River.

Macroscopic.—Coarse grained dark rock with porphyritic felspars, showing fluxional arrangement.

Microscopic.—Plagioclase, augite (uralite), ilmenite, magnetite, rutile. The structure is granitoid, but there are two generations of felspars. The felspar is much decomposed into saussuritic material. The augite is largely uralitized, and, with the felspar, makes up the bulk of the slide. The ilmenite is much altered to leucoxene.

In conclusion I wish to express my thanks to all those who have helped me in the work of preparing this paper. Particularly I should like to mention Mr. Reginald Cleveland and Mr. James Bowling, residents of King Island, for help in pointing out interesting localities, and Mr. L. K. Ward, B.A., B.E., for much advice given on the lithological resemblances to the rocks of Tasmania. My thanks are especially due to Dr. W. G. Woolnough for much advice and assistance in the preparation of this paper.

NOTES ON AZURITE CRYSTALS FROM BROKEN HILL.

By Miss F. COHEN, B.A., B.Sc.,
Junior Demonstrator in Geology and Mineralogy,
University of Sydney.

With Plates XXXVI, XXXVII.

[*Read before the Royal Society of N. S. Wales, November 2, 1910.*]

Azurite from Broken Hill.—The crystals dealt with in this paper were, with one exception, obtained from the specimens in the Hugh Dixson Collection of Minerals from Broken Hill, lately presented to the University of Sydney. Some azurite crystals from the same locality have already been described by Dr. Const Steiner,[1] but in view of the wealth of material in the above collection it seemed desirable that they should receive further investigation. The crystals measured were taken indiscriminately from several hand specimens, and for the purposes of description may be divided into two types. All are small crystals and the faces possess bright, well-reflecting surfaces, with the exception of a few which are invariably striated. I have also measured a third type from Broken Hill, kindly placed at my disposal by Dr. Anderson, Mineralogist of the Australian Museum, Sydney.

Type I.

Of this type four crystals were examined. Three of these are small, measuring approximately ·75 × 4 × 1·5 mm. in the direction of the *a*, *b* and *c* axes respectively. The fourth, however, is somewhat larger. All are elongated in the direction of the *b* axis and distinctly tabular on the *a* pinacoid. The following forms were observed *a* (100), *ϕ* (201), *c* (001), *θ* ($\bar{1}$01), *η* ($\bar{3}$02), *v* ($\bar{2}$01), *m* (110), *w* (120), *h* (221), *l* (023), *f* (011), *p* (021), *s* (111), *u* ($\bar{2}$23), *k* ($\bar{2}$21).

[1] Ann. Mus. Nat. Hung., IV, 1906, p. 293-8.

Figs. 1 and 2 show a typical crystal in orthographic and clinographic projection respectively. Fig. 3 is an orthographic projection on the plane containing the *a* and *c* axes.

Type II.

Crystals of this type also are elongated in the direction of the *b* axis, but instead of being tabular on the *a* pinacoid, they are prismatic in habit, the cross section at right angles to the *b* axis being more or less square. Two crystals were measured, both possessing all of the following forms:— *a* (100), ϕ (201), σ (101), *c* (001), θ $(\bar{1}01)$, η $(\bar{3}02)$, *v* $(\bar{2}01)$, *m* (110), *w* (120), *h* (221), *l* (023), *f* (011), *p* (021), *s* (111), *k* $(\bar{2}21)$, *u* $(\bar{2}23)$, *R* $(\bar{2}41)$.

Fig. 4 represents an orthographic projection—the crystal being held with the *b* axis vertical and the *a* axis running right and left.

Types I and II are thus seen to have many points of similarity, the forms being practically identical and the faces having almost the same degree of development. The predominant forms are *a* ϕ *c* θ η *v m h l f p*, which are present on all the crystals measured. Of these the *a* and *c* pinacoids possess by far the largest faces—*a* being the larger of the two and invariably striated, while *c* is perfectly smooth and gives excellent reflections. Considering the orthodome zone, ϕ and θ show the greatest development. ϕ is always large and smooth, θ often striated, η and *v* invariably so. σ occurs only on a few crystals and is somewhat narrow but smooth.

On all the crystals measured a negative orthodome is present intermediate in position between *c* and θ. On one crystal two readings for the angle between this face and the *a* pinacoid were obtained, viz., 74° 17′ and 74° 50′. This may be, therefore, a new face $\bar{4}\cdot0\cdot13$. Another crystal gives readings 82° 06′ and 82° 51′ and may be another new face $\bar{1}06$. On all the other crystals, the readings are very

conflicting—all the more so as they do not agree on opposite sides of the crystal, being invariably much higher on the one side than on the other. A mean of the results obtained gives the angle between this face and the *a* pinacoid as 73° 46′ on one side and 78° 33′ on the other, which are closest to *A* ($\bar{1}03$) and *D* ($\bar{1}04$) respectively.

The Clinodomes are represented by *l*, *f* and *p* which are present on all the crystals examined. *l* is smooth, narrow and rectangular in shape. *f* is always larger than *l* and in general is six sided and strongly striated, owing to oscillatory combination with *l*. *p* always occurs as small triangular faces.

Of the prism faces *m* is always very large and gives excellent readings. *w* occurs only in a few cases and is small and four sided. Of positive hemipyramids *h* is by far the more important. It occurs as large four or six sided faces, while *s* is very much smaller and in general rectangular. The negative hemipyramids are represented by *u*, *k* and *R*, they are all small faces, *u* being invariably triangular, but sometimes four sided, while *k* and *R* are four sided—*k* being much broader than *R*.

Type III.

This crystal is of different order of size to Types I and II, measuring approximately 8 × 25 × 9 mm. in the direction of the *a*, *b* and *c* axes respectively. In habit it is very similar to Type II, inasmuch as it is elongated in the direction of the *b* axis and is prismatic. It is, however, characterised by the presence of a large negative hemipyramid λ ($\bar{2}\cdot18\cdot3$), and also of a very large negative orthodome *D*($\bar{1}04$); other forms present are $a\ \phi\ \sigma\ c\ \theta\ \eta\ v\ l\ f\ p\ m\ h\ s\ P$ (223).

Figs. 5 and 6 represent a clinographic and orthographic projection respectively with the *b* axis vertical, and the *a* axis running right and left. *a* is again the largest face and is very much striated.

Orthodomes.—ϕ in distinction to types I and II is narrow while σ is large and smooth and gives excellent reflections. D is a large face—very striated, and gives a train of signals, the angle $a \wedge D$ varying between 80° 37′ and 69° 54′. It interoscillates with c, the latter appearing as a narrow strip in the middle of D. ϕ, η and v are all well developed and on this crystal show no striations at all.

Clinodomes are again represented by l, f, and p. All are unstriated and give excellent readings. The prism m and the hemipyramid h are large and well developed as before. s occurs as a large five-sided face, and the edge between s and c is truncated by the hemipyramid P (223). The latter is a very distinct trapezoid face, giving an excellent signal, and has not been previously recognised on azurites from Broken Hill.

Crystals of this type have been described and figured by Van Name and Penfield.[1] In addition to the above forms they recognised w (120), ρ ($\bar{1}34$), k $\bar{2}21$ and R ($\bar{2}41$) but do not find σ (101) and P (223). Cesàro[2] has described a similar crystal from Broken Hill possessing the characteristic faces λ and D.

Summary.—The three types of crystals that were investigated show a great similarity of habit. All possess the same essential forms and the faces have practically the same degree of development. Type II certainly seems to be intermediate in position between types I and III, and hence the mere possession of a couple of extra faces does not seem to be sufficient to put the crystals into different classes. Therefore looking at them from a broad point of view, they are all practically of the same habit, viz., elongated in the direction of the b axis and more or less tabular on the a pinacoid, which is always the largest face.

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[1] Amer. Journ. Sci., XIV. 1902 p. 277–280.
[2] Bull. de l'Acad. Roy. de Belg. 1905, p. 133–135.

Steiner recognised three habits, but his types I and II seem very similar and almost identical with type I as described in this paper. As regards the forms present Steiner found, in addition, the faces γ (121), α ($\bar{1}21$), j (045) κ ($\bar{4}03$), p ($\overline{15}\cdot0\cdot8$), $\mathfrak{M}$ ($\overline{13}\cdot0\cdot6$), but did not find the faces P (223) and λ ($\bar{2}\cdot18\cdot3$) or the possible new faces ($\bar{4}\cdot0\cdot13$) and ($\bar{1}06$).

The crystals were all measured on the two circle goniometer and were oriented with the orthodome zone horizontal and the a pinacoid vertical. The co-ordinate angles then had to be calculated from the observed readings of the horizontal and vertical circles.

The elements as calculated from the faces ϕ θ η m w h k s u P R l f p give the following results—

$$a:b:c = 0\cdot856085:1:0\cdot885852$$

The average measured angle for β is 87° 38′.

Below is a table of the forms observed, the average ϕ and ρ angles and the theoretical ϕ and ρ angles calculated from the indices and elements. Figure 7 is a stereogram, the projection being made on the plane of symmetry.

Forms.		ϕ		ρ		Calculated. ϕ		Calculated. ρ		Error. ϕ	Error. ρ
		°	′	°	′	°	′	°	′	′	′
a	100	90	0	90	0	90	0	90	0	0	0
ϕ	201	90	0	64	37	90	0	64	40	0	3
σ	101	90	0	47	08	90	0	47	07	0	1
c	001	90	0	2	22	90	0	2	22	0	0
*	$\bar{1}06$	$\overline{90}$	0	7	31	$\overline{90}$	0	7	29	0	2
D	$\bar{1}04$	$\overline{90}$	0	11	27	$\overline{90}$	0	12	16	0	49
*	$\bar{4}.0.13$	$\overline{90}$	0	15	31	$\overline{90}$	0	15	30	0	1
A	$\bar{1}03$	$\overline{90}$	0	16	14	$\overline{90}$	0	16	54	0	40
θ	$\bar{1}01$	$\overline{90}$	0	44	50	$\overline{90}$	0	44	50	0	0
η	$\bar{3}02$	$\overline{90}$	0	56	32	$\overline{90}$	0	56	32	0	0
v	$\bar{2}01$	$\overline{90}$	0	63	39	$\overline{90}$	0	63	47	0	8
l	023	3	59	31	09	4	00	30	38	1	31
f	011	2	57	41	16	2	41	41	34	16	18

Forms.						Calculated.				Error.	
		φ		ρ		φ		ρ		φ	ρ
		°	′	°	′	°	′	°	′	′	′
p	021	1	28	60	34	1	21	60	34	7	0
m	110	49	26	90	0	49	28	90	0	2	0
w	120	30	22	90	0	30	19	90	0	3	0
h	221	49	48	70	02	50	01	70	04	3	2
s	111	50	42	54	22	50	34	54	22	8	0
u	$\bar{2}23$	$\overline{47}$	59	41	25	$\overline{47}$	43	41	17	16	8
k	$\bar{2}21$	$\overline{48}$	46	69	36	$\overline{48}$	53	69	38	7	2
R	$\bar{2}41$	$\overline{29}$	36	76	15	$\overline{29}$	49	76	14	13	1
λ	$\bar{2}.18.3$	$\overline{6}$	31	79	20	$\overline{6}$	53	79	25	22	5
P	223	51	31	43	07	51	06	43	15	25	8

Faces marked with an asterisk are possible new forms.

The observed combinations are shown in the following table:—

Forms.	Indices.	Crystal No.:— 1	2	3	4	5	6	7
a	100	*a*	*a*	*a*	*a*	*a*	*a*	*a*
φ	201	φ	φ	φ	φ	φ	φ	φ
σ	101					σ	σ	σ
c	001	*c*	*c*	*c*	*c*	*c*	*c*	*c*
D	$\bar{1}04$			*D*		*D*	*D*	*D*
θ	$\bar{1}01$	θ	θ	θ	θ	θ	θ	θ
η	$\bar{3}02$	η	η	η	η	η	η	η
v	$\bar{2}01$	*v*	*v*	*v*	*v*	*v*	*v*	*v*
l	023	*l*	*l*	*l*	*l*	*l*	*l*	*l*
f	011	*f*	*f*	*f*	*f*	*f*	*f*	*f*
p	021	*p*	*p*	*p*	*p*	*p*	*p*	*p*
m	110	*m*	*m*	*m*	*m*	*m*	*m*	*m*
w	120					*w*	*w*	
h	221	*h*	*h*	*h*		*h*	*h*	*h*
s	111			*s*		*s*	*s*	*s*
u	$\bar{2}23$	*u*	*u*	*u*		*u*	*u*	
k	$\bar{2}21$		*k*			*k*	*k*	
R	$\bar{2}41$					*R*	*R*	
λ	$\bar{2}\cdot18\cdot3$							λ
P	223							*P*

In conclusion I desire to express my indebtedness and sincere thanks to Dr. W. G. Woolnough of the University of Sydney, and Dr. C. Anderson of the Australian Museum, Sydney, for their constant help and advice and their kindness in placing the specimens at my disposal.

EXPERIMENTS WITH SILICATE OF SODA AND OBSERVATIONS THEREON.

By W. J. CLUNIES ROSS, B.Sc. Lond., F.G.S.

With Plates XXXVIII, XXXIX, XL.

[*Read before the Royal Society of N. S. Wales, December 7, 1910.*]

ABOUT two years ago I exhibited at one of the Society's meetings some growths which I had obtained by placing crystals of various salts in a weak solution of silicate of soda (water glass). The exhibit excited considerable interest, and those present could offer no explanation of the phenomena observed. Since then I have continued my experiments and have also consulted a good deal of literature to find out if systematic work has been done upon the subject. Beyond allusions in one or two text books to the fact that crystals develop shoots when placed in silicate of soda, I have found nothing of importance. It appears to me, therefore, advisable to place on record the results I have obtained so far, especially as I regard them not merely as curious facts, but as worthy of systematic study and discussion, as to the causes to which they are due, and also as tending possibly to throw light on phenomena connected with chemistry, physics, geology, and it may be

biology. We may first consider how the experiments are carried out. Next, what are the results obtained? Then we may consider any possible or probable way of accounting for them, and finally, any possible connection with natural phenomena.

Method of Conducting Experiments.—A solution of ordinary water glass, such as is sold for preserving eggs, is taken and diluted with water to a known density. I generally use a Twaddell's hydrometer to test density, and have tried solutions from 4° to 26° Tw., that is, from 1·02 to 1·13 sp. gravity. I find if the solution is very weak the growth is slow or does not take place at all, while if very strong it does not usually go on well. A solution of about 16° Tw., 1·08 sp. grav., is found to be the most generally useful strength, and although some salts may grow better in rather weaker solutions and others in stronger, yet I have thought it better to keep, in the main, to one strength, and most of the experiments hereafter described, have been carried out with the 16° solution.

Having obtained our solution and placed it in a test tube or other similar vessel, we drop in a crystal or crystals of the salt we desire to experiment with and await results. After a time, it may be a few minutes, as in the case of aluminic chloride, it may be nearly a week, but usually in the course of an hour or two, growth begins and goes on for some time and then stops. Usually salts which begin quickly soon attain their full growth, while those which begin slowly may take a week or more and still show signs of change. The solution usually remains quite clear, and although coloured salts give coloured growths, the colour rarely passes into the solution. If, however, strong hydrocloric acid be added to the solution a notable change occurs. The base of the salt appears to go into solution, which becomes coloured, while the growths usually retain their

original form. The liquid passes into a firm jelly, often enclosing bubbles of gas which may remain attached to the shoots, looking sometimes like fruits on a stem.

Results.—Salts of the following metals have been tried: Antimony, bismuth, mercury, silver, cadmium, copper, lead, aluminium, iron, chromium, nickel, cobalt, manganese, zinc, barium, strontium, calcium, magnesium, uranium, yttrium, zirconium, cerium, molybdenum, tungsten, and thorium. The results obtained are very different with different salts, and it is this which first directed my attention to the matter and led me to make systematic experiments. It would be too much to say that in every case one can, on seeing a growth, state at once the salt that produced it, yet in many cases this may be done.

Some salts, especially those of metals which form acid oxides, and those which rarely occur in nature as silicates, give scarcely any growths. Antimony, tin, and bismuth are among these, while silver and mercury grow very slowly or scarcely at all. Moreover, insoluble salts do not grow. In most cases, although with some exceptions, the base alone determines the growth, the acid having little effect.

The results obtained with the salts of metals which have yielded definite growths may be briefly summarised:—

Silver—The nitrate was used; turns dark in colour; gave one slender shoot after long standing.

Mercuric salts—The chloride turns dark red, gives a few thick branching shoots.

Mercurous nitrate—Turns dark, swells, a few fine threads produced.

Lead—The nitrate and acetate were tried, gives slender, distinct, white shoots, usually not more than an inch. Occasionally grows very fast.

Cupric salts—Grow well, Sulphate long slender blue shoots. Better in weak than strong solutions. Chloride green, rather thick shoots, four to six inches. If both salts together, the sulphate does not grow well. But a good growth of sulphate will check the chloride.

Ferrous sulphate and *chloride*—One of the most characteristic growths. At first white, soon turning dark, about three to four inches, interlacing slender shoots forming a kind of bush. The chloride and sulphate are quite alike.

Ferric chloride and *sulphate*—A great contrast to the ferrous salts. The salts swell up and form red fungoid growths, rarely reaching more than an inch in length.

Chromic chloride and *sulphate*—Merely swells up or may give a poor growth.

Aluminic sulphate and *chloride*—The sulphate shews little effect, scarcely giving distinct growths. The chloride on the other hand, grows very quickly, forms thick soft looking shoots which may grow to a foot in length. The shoots are fragile, and the upper part often breaks off and sinks to the bottom.

Cobaltous nitrate and other cobaltous salts gives slender violet shoots from two to four inches long.

Nickelous sulphate and other nickelous salts. A great contrast to cobalt. Usually swells up, but sometimes gives a few short, thick stems barely an inch in length, of a bright green colour.

Manganous sulphate and *chloride*—Mostly long slender shoots, four to six inches, pale brown colour. Solution becomes slightly coloured. In one case a thick shoot expanding at the top was given.

Zinc sulphate grows quickly, white, thick, sometimes branching, shoots up to six inches or more. Chloride grew slowly at first, then very vigorously.

Cadmium sulphate—Very slender, delicate shoots, about four to five inches. A great contrast to zinc. Cadmium iodide also grows well.

Barium and *Strontium*—Nitrate and chloride seldom grow at all well, but in general resemble calcium.

Calcium chloride, both hydrated and anhydrous, grows rapidly. At first usually slender thread-like shoots; after a time the solution becomes milky, and a white feathery precipitate separates, gradually becoming thicker and settling down, but the threads may remain distinct.

Magnesium is disappointing. One would expect it to grow well, but it rarely does more than give off a few short shoots, the rest merely swelling up. Both the sulphate and the chloride have been tried.

Uranium—Uranylic nitrate $UO_2\,(NO_3)_2$ and acetate have been tried. The salt turns a bright yellow, swells up but does not send out shoots.

Zirconium and *Yttrium*—Nitrates have been tried, and both gave a good growth, about two to three inches long. Zirconium rather thick. In a taller tube it did not grow so well. Cerous sulphate gave one or two feeble, pale brown shoots.

Consideration of Results.—Having summarised the results obtained, we may now consider whether there is any reasonable explanation of the phenomena observed, and if there are any similar growths obtainable in other ways. We have to account, if we can, for the growth, against the action of gravity, of long and often very slender shoots, which having grown to a certain length may remain in many cases, for apparently an indefinite time, at least for several years, if kept in a stoppered tube, without apparent change. Moreover, some of the growths, and especially the slender ones are very firm, so that the tubes

may be laid on their side and carried about without breaking the shoots.

The solution is always alkaline, and as most of the salts which grow well are also precipitated by caustic soda it might be thought that perhaps we were merely dealing with ordinary precipitates. It is found, however, that adding solutions of salts of the metals to a solution of water-glass gives altogether different results to those obtained on dropping a crystal of the same salt into the solution. In the former case a gelatinous precipitate usually forms, but this disappears on shaking, or it may be is suspended as a, possibly, colloidal solution. In one or two cases the precipitate remains, but these are not the salts which give the best growths. Thus, uranium nitrate gives dense yellow flocks on adding it to a solution of silicate, and these appear to be similar to what is produced on dropping in crystals, but there is scarcely any growth in the latter case. A fair number of the salts while giving precipitates with caustic soda are soluble in excess of the reagent. Yet such salts, *e.g.*, zinc chloride or sulphate, aluminic chloride, and cobalt nitrate grow well and quickly.

A more probable suggestion is that growth is due to the formation of a semi-permeable membrane. We may consider some phenomena which at first sight bear considerable analogy to those with which we are dealing. If sulphate of copper, powdered, be mixed with a little sugar moistened to a paste, and then allowed to dry, a hard mass is formed. A piece of this carefully dropped on to a solution of ferro-cyanide of potassium often floats. In a few minutes a brown shoot protrudes, and in the course of an hour or two may grow to a length of three or four inches. The shoots are, however, very tender, and a slight shake will generally cause them to break off and fall to the bottom of the glass. If the piece of sugar mixture sinks, it may grow up from

below or may expand into delicate cell-like structures. These phenomena have been extensively studied in France, but I have not seen the original papers. In the description I read, it was said that gelatine should be added to the ferrocyanide, but I have not found it necessary to do so. In this case we are probably dealing with a semi-permeable membrane of cupric ferrocyanide, so well known in connection with osmotic pressure experiments. This membrane allows the water to pass into the cavity behind the membrane but does not allow the sugar solution to pass out, and the gradual stretching of the membrane apparently allows the precipitation of more ferrocyanide and so the growth goes on.

Allusion may also be made to some experiments by Prof. Leduc, of Naples, said to have been exhibited at the French Physical Society. The results are obtained by pouring a solution of gelatine on a glass plate and adding a drop of some salt solution. Very beautiful patterns are said to be formed. I have tried to repeat some of the experiments and with fair success. Assuming the semi-permeable membrane theory as a working hypothesis, we may suppose that a thin membrane of a silicate of the base is first formed where the solution of salt and silicate meet. This may permit the water of the silicate solution to pass in but not allow the salt solution to pass out, and the membrane became stretched, as suggested above. In support of this view we have the fact that coloured salts, such as ferrous sulphate, cupric sulphate, cobalt nitrate, give coloured growths, but do not colour the solution outside, nor give a precipitate there. Manganese may be an exception. It appears always to pass out sufficiently to colour the solution a pale brown. It is interesting to note that some recent physiological work appears to indicate that manganese salts may be exceptional in their power of passing through membranes.

With very quick growers, such as aluminic chloride, one can see a very thin colourless, almost invisible, membrane apparently streaming out from the top of the shoots while one watches, looking like a plant cell or sometimes like a small *Medusa*. This gradually seems to thicken and become opaque. Similar observations may be made by forming a little cell with parafin wax on a microscope slide, introducing a little silicate solution, adding a small crystal, and covering with thin glass, then observing with a pocket lens or low power microscope. I tried this method in order to see if possible whether there were any indications of crystals being produced, but could see none, either during growth or after growth appeared to have ceased. There were no outlines of crystals, but when dried the structure appeared to be of the nature of rounded nodules. It appears almost certain that the precipitate forming the growth is a silicate of the base, but one in which the basic oxide is only loosely associated with the silica, since hydrochloric acid dissolves out the base and leaves the silica, which usually retains the shape it first assumed, although in some cases it appears to sink down into a gelatinous looking mass.

A careful analysis of the growth would be interesting, but it is not easy to get a pure specimen, on the one hand free from the unaltered salt, and on the other from the silicate of soda. I have made one or two rough determinations of the silica contents of the firmer growths, such as ferrous and cupric salts. I poured off the silicate solution, after growing a small crystal, washed the growth that remained with water, dried and then estimated the anhydrous silica in the usual way. I obtained approximately 50 per cent. anhydrous silica, but I hope to make more detailed and accurate determinations.

Whatever may be the agency producing growths, it appears that the shoots must be tubular, the solution of

salt passing up inside. The tubes must be very narrow in the case of such salts as cadmic sulphate, which gives filaments almost as fine as hair. These wave about in the solution but do not thicken or break. Very fine detached filaments also grow very fast. While one may offer suggestions as to the possible agency producing some of the growths, I know of no explanation to account for the very different forms assumed by the various salts, and especially why salts of metals generally supposed to be related chemically, behave quite differently. Thus cadmium gives long slender filaments, zinc soft thick shoots. Cobalt grows freely in long threads; nickel gives fungoid or short thick shoots; ferrous salts grow very freely; ferric in thick fungoid forms.

It occurred to me that possibly the growths might push themselves between the grains of stone. One might thus obtain food for speculation as to whether something of the kind might not take place in nature. I accordingly placed some silicate solution, together with a crystal, on top of a small cube of sandstone. The crystal swelled but gave little satisfaction, I then placed the cube in solution just deep enough to cover it, with crystals beside it. Copper, iron and cobalt sent out shoots which became firmly adherent to the stone but did not appear to penetrate. I then tried a specimen of shale in silicate solution. Copper again grew, but did not penetrate between the laminae. I hope to pursue the subject further. A method which is said to be in use for preserving wood, viz., to saturate the wood with silicate of soda and then place in a solution of iron, which forms a coating of silicate of iron, might be tried, but it is doubtful if true shoots would form.

I am conscious that the results I have brought forward are in many ways incomplete, and that much more remains to be done in connection with the subject. I have only

been able to carry on the experiments intermittently and it is likely that it will be sometime before I am able to follow up the subject systematically. I propose to try experiments with other solutions to see if I cannot get similar growths. But in the meantime it seemed worth while to place on record the results I have obtained, and it is open to anyone to develop the matter further. My assistant, Mr. H. A. Harding, who first called my attention to the growths, has carried on a similar series of experiments, but quite independently. His results accord very well with mine. He is also pursuing the subject and making some analyses in connection with it.

ON THE AUSTRALIAN MELALEUCAS AND THEIR ESSENTIAL OILS, Part III.

By RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

With Plates XLI, XLII, XLIII, XLIV, XLV, XLVI, XLVII, XLVIII.

[*Read before the Royal Society of N. S. Wales, December 7, 1910.*]

1. *M. trichostachya*, Lindl.
2. *M. bracteata*, F.v.M.
3. *M. styphelioides*, Sm.

Introduction.—This paper is the outcome, more particularly of Part I of this series, which includes *M. linariifolia*, for some of the material here described was collected under that name, but the investigation early showed that in this connection two distinct species were being dealt with, and the matter was held over for further enquiry. Since then

material has been obtained from other localities, which confirmed our suspicions, and led in this case to the restoration to specific rank of Lindley's *M. trichostachya.*

M. styphelioides, Sm. was next investigated, and this appears to be a sound species, both morphologically and chemically. However, some of the material which was placed tentatively with it, was found afterwards to differ considerably in several respects, and in this case also differentiation had to be resorted to in order to systematically place the results. The outcome of it was that Mueller's *M. bracteata* was separated from not only *M. styphelioides*, which, in Mueller's and our opinion, it somewhat resembles morphologically, but also from *M. genistifolia*, with which species, however, Bentham regards it more closely related.[1]

The characters upon which our classification is founded are detailed under each species, and as in Parts I and II of this series of papers, chemistry and anatomy enter largely into the evidence adduced to warrant such a classification.

(1) *Melaleuca trichostachya*, Lindl., in Mitch. Trop. Aust. 277.

Historical.—In 1797, Smith described in Trans. Linn. Soc. of London, III, p. 278, a species of Melaleuca under the name *M. linariifolia.* This shrub is fairly common in the County of Cumberland, and especially Port Jackson where it was collected by Robert Brown.

In 1846, Mitchell collected a Melaleuca at Belyando River, which was described by Lindley, *loc. cit. supra.* This was synonymised by Bentham and Mueller in the Flora Australiensis, Vol. III, p. 141, under Smith's species, as var. *trichostachya*, with localities Belyando River, Mitchell, Burdekin and Gilbert Rivers, and along the North-east Coast, F. Mueller; Cooper's Creek, Howitt's Expedition.

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[1] Flora Australiensis III, p. 144.

To these are now to be added Gladstone, Queensland (T. D. Ferguson); and Angledool, New South Wales, (A. Paddison). However, Mueller in his Second Census, 1889, p. 94, recognises its specific rank. Bailey, Queensl. Fl., Vol. II, p. 600, gives it varietal rank, the same as Bentham, *loc. cit.* As the result of these investigations it would now appear that there is sufficient evidence to warrant the systematic separation of these two species. Bentham under the circumstances could only classify on morphological grounds, and even in this instance was not prepared to wholly suppress Lindley's species, but gave it, as stated above, varietal rank.

Melalcuca linariifolia appears to be more limited in its geographical distribution than *M. trichostachya*, which extends over a wide area of country, as it occurs on the north-east coast of the continent and over the main divide to Cooper's Creek, a rather unusual range,—from the moist coast region to the arid interior, and yet is constant in character throughout.

Systematic.—It is a medium sized tree, one to two feet in diameter, growing on river banks, with a close, laminated bark (A. Paddison). Young shoots pubescent, leaves very narrow, linear lanceolate, opposite, occasionally concave and often with incurved points, venation scarcely discernible although the midrib is sometimes distinct, and two other ribs less prominent, about one inch long. Flowers in opposite pairs, on an interrupted spike, small. Calyx, glabrous, hemispherical. Lobes about the same length, shortly acuminate. Petals imbricate in the bud, rather shorter than the calyx. Staminal columns about two lines long, the claws comparatively short, with numerous filaments. Style about the length of the staminal column. Full matured fruit, hemispherical or cup-shaped, valves exserted, rim thin.

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It is easily differentiated in the herbarium from *M. linariifolia*, both by leaves, fruits and inflorescence, and Bentham no doubt saw the distinction when he was moved to give it varietal rank. Mueller also regarded it as specifically distinct (*supra*).

M. linariifolia has thicker branchlets, larger leaves and spikes, and is altogether a more robust plant in herbarium specimens, although not so large a tree, judging from data available. Anatomically the difference is quite pronounced as shown under leaf anatomy of each in this series of papers.

Leaf Anatomy.—A transverse section of leaf is evenly divided in the long axis into three equal and parallel portions, the median part being occupied by the spongy mesophyll, and the two outer by the palisade parenchyma. Through the central structure from edge to edge of the leaf run the bundles, the central one being slightly larger than the others. Each is more or less surrounded by a number of sclerenchymatous cells, no transfusion tissue being detected. A manganese compound is a prominent feature in many of the cells of the spongy mesophyll, and is indicated by dark patches in the sections shown. The pallisade parenchyma is very solid, being sometimes three cells deep, and irregularly scattered through it occur proportionately large oil glands. The stomata are found on both surfaces, embedded in the epidermal cells. The oil glands are fairly well scattered throughout the leaf tissue, and are of a lysigenous origin; the secretory cells are long and narrow in section.

Essential Oil.—The leaf oil of this species of Melaleuca (*M. trichostachya*) is of considerable commercial importance, as it is one of the richest in cineol content of any known essential oil. It compares favourably in this respect with the best cineol bearing Eucalyptus oils, as *E. Smithii*,

E. polybractea, and other oils of this class now used for pharmaceutical purposes. It has an advantage, too, in colour over many of these oils, such as those of *E. globulus*, *E. goniocalyx*, and similar species of this group, as the oils distilled from these are often tinged yellow, while the rectified oil of this Melaleuca is water white, and agrees in this respect more closely with the oils of *E. amygdalina*, and the more pronounced terpene-oil yielding species of the genus Eucalyptus. It is indeed difficult to detect any differences in physical or chemical properties, except perhaps that of colour, between the rectified oil of this Melaleuca and the best cineol bearing Eucalyptus oils so far known. The range of the species, too, is somewhat extensive in Eastern Australia, and we give herewith analyses of two samples of oil, one distilled by us from material sent to the Technological Museum by Mr. T. D. Ferguson of Gladstone, Queensland, in May of this year, and the other from material collected at Port Macquarie, New South Wales, last November. Although these localities are hundreds of miles apart, yet, the characters of the oils vary in no degree from each other, except in that of yield, and this is due more largely to the difference in the time of year when the material was collected. The month of November is generally recognised in Eastern Australia as being better for yield of oil from Myrtaceous plants than is June, the latter month being the middle of the Australian winter. The results of this investigation is another confimation of the comparative constancy of chemical products obtainable from identical species, belonging to genera of the Myrtaceae family, and growing under natural conditions.

The leaves of this Melaleuca are comparatively small, and thin, and the oil glands large, consequently the oil can be easily separated by steam, and it comes over rapidly, so

that no advantage is gained by prolonged distillation. The oil contains but a trace of acid, and as the amount of ester is also very small, there is nothing to attack the metal of the still, and consequently the crude oil is but slightly coloured. The low boiling aldehydes are also only present in traces, so that the crude oil is practically free from these somewhat objectionable constituents. As this Melaleuca only grows as a shrub or small tree, the material for distillation would be easy to collect, and consequently could be distilled at a very cheap rate, especially as it yields such an abundance of oil.

The leaves of the Port Macquarie trees are generally more robust looking than those of the Queensland material, and this might be thought to be due to the southern location of the New South Wales plants; but there is possibly another explanation, and that is the stimulating effect of an increased amount of manganese in the leaves of the southern trees over those of Queensland. Just what part manganese plays in the economy of plants is not yet known, but it is now shown to be a very constant constituent in the ash of those Australian trees so far tested, particularly in the Coniferae. The quantitative determination of the manganese in the ash was carried out by boiling 0·03 gram. with lead dioxide and nitric acid as described in our "Research on the Pines of Australia," page 83, where this matter is somewhat fully dealt with. The amount of Mn. in the dark brown ash of the leaves alone of the New South Wales Melaleuca was 0·166%, and in the ash of the leaves alone of the Queensland sample it was 0·047%, or more than three times as much in the New South Wales material. In the woody twigs of the Queensland plants, without the leaves, the amount of Mn was 0·037%. Whether an increased amount of manganese is partly responsible for the increased yield of oil is a question yet

to be decided, but it certainly has no influence on its composition.

Experimental.—The material received from Gladstone, Queensland, came to Sydney by sea, and it was quite dry when it reached us; 107 lbs. of leaves and terminal branchlets gave $21\frac{1}{2}$ ounces of oil, equal to 1·25%. The material from Port Macquarie was also quite dry when distilled, and 252 lbs. of leaves and branchlets gave 104 ounces of oil, equal to 2·58%. The close agreement of the two crude oils can be seen from the following results:—

Locality.	Sp. gravity at 15° C	Rotation, α_D	Refractive index, 20° C.	Solubility in alcohol by weight.
Gladstone, Queensland, May, 1910.	0·9144	+ 2·3°	1·4636	1·3 vols. 70%
Port Macquarie, N. S. Wales. November, 1910.	0·9153	+ 3·1°	1·4655	1·3 vols. 70%

When the crude oil of both samples was dissolved in eight or ten volumes acetic acid and bromine added in excess, after a very short time the mixture became reddish, then violet, and soon of a deep indigo blue, which colour remained permanent for a long time.

The crude oil of *M. thymifolia*[1] does not appear to give this colour reaction, although in general characters it closely approaches the oil of this Melaleuca. The colour reaction is given readily with the oil of *M. uncinata*, but not so distinctly with that of *M. linariifolia.*

For distillation, 100 cc. of the oil of the Gladstone sample were taken, about 1 cc. came over below 173° C. (corr.); the thermometer then slowly rose to 176° by which time 50 cc. had distilled; between 176 – 178° 30 cc. more came over, and between 178 – 184° 10 cc. distilled; between 184 – 195°

[1] Proc. Roy. Soc., N.S.W., 1906, p. 62.

4 cc. were obtained; these were all separated as one fraction equal to 94% of the total oil. The 5 cc. left in the still were taken as remainder. 100 cc. of the oil from the Port Macquarie material was similarly distilled, with nearly corresponding results, although with the large fraction only 90% distilled below 195° C.

The distilled oil from both these samples was water white and had an odour closely resembling those Eucalptus oils richest in cineol. The small amount of water which came over with the first few drops was slightly acid, and the odour of the lower boiling aldehydes was detected, although this was not very pronounced, nor was it very objectionable. The aldehyde reactions were also readily obtained. The large fractions gave the following results:—

	Specific gravity at 15° C.	Rotation a_D	Refractive index at 20° C.
Gladstone sample ...	0·9123	+ 2·0°	1·4614
Port Macquarie sample	0·9125	+ 2·8°	1·4620

The reactions for cineol were most marked, the phosphoric acid compound becoming quite dry and powdery. The quantitative determination of the cineol was made by the resorcinol method, with the oil distilling between 173 – 195° C., and calculated for the whole oil; with the Gladstone sample the cineol in the whole crude oil was 81% by this method, and in the Port Macquarie oil it was 80%. The specific gravity of the residue in the still, of the Gladstone sample, was 0·9394, and it had a refractive index 1·4924. The specific gravity of the residue of the Port Macquarie oil was 0·9378, and the refractive index 1·492 at 20° C.

In the determination of ester in the Gladstone oil with boiling alcoholic potash, 3·932 gram required 0·0084 gram KOH, or saponification number 2·1. With the residue 1·538 gram required 0·0126 gram KOH or S.N. 8·2. The crude oil of the Port Macquarie sample gave S.N. 2·8. The amount

of ester in the oil of this Melaleuca is thus very small. The odour of the saponified oil of the residue was quite aromatic.

For the determination of the free alcohol the crude oil of the Gladstone sample was acetylated by boiling with acetic anhydride and anhydrous sodium acetate in the usual way. The oil was thoroughly washed and dried, when 3·0144 gram required 0·042 KOH, or S.N. 13·9. The residue was also acetylated, when 1·7341 required 0·0938 gram KOH or S.N. 54·1. It is thus seen that the alcohol present is a high boiling one.

The identity of the active terpene was not determined; it was, however, not phellandrene as with the Oakey Creek oil, and when the crude oil was treated with sodium nitrite and acetic acid it developed the bright green colour similar to that given by *E. globulus* and other Eucalyptus oils of this class. It may thus be partly pinene. The acid of the ester is acetic acid. It was obtained by saponifying the high boiling residue from 300 cc. of oil, removing the adhering oil by ether, acidifying with sulphuric acid, separating the small amount of a phenol present, and distilling over the volatile acid. The distillate was then neutralised and evaporated to small bulk. The reactions given were entirely those for acetic acid. Cinnamic acid or other solid acids were not detected.

The oil after saponification was washed, dried and distilled; 2·5 cc. came over between 218–225° C.; the temperature then quickly rose to 250°, between this and 255° C.; 3 cc. distilled. The first fraction gave the characteristic odour of terpineol most distinctly. It had specific gravity 0·931 at 15° C., and refractive index 1·484 at 20° C. When agitated with hydriodic acid a small amount of a crystalline substance was eventually obtained, which melted at about 77° C., and was most probably dipentene dihydriodide, thus confirming the presence of terpineol. These results

are sufficient to show that the ester of the oil of this Melaleuca consists mostly of terpinyl-acetate, thus corresponding to that of ordinary "Cajuput," also distilled from a species of Melaleuca. The second fraction was probably a sesquiterpene, it had specific gravity 0·934, and refractive index 1·4985. It is the constituent which gives the marked colour reaction with bromine in acetic acid. The phenol was present only in traces, it gave a dark green to brownish green coloration with ferric chloride in alcoholic solution, but did not indicate either eugenol or carvacrol.

(2) *Melaleuca bracteata*, F.v.M., Frag. I, 15.

Historical.—This species was described by Mueller, *loc. cit.*, in 1858-9 from a New South Wales plant—a specimen of which is now extant in the National Herbarium, Sydney. Bentham in the Flora Australiensis, Vol. III, p. 144, places Mueller's determination as a synonym of *M. genistifolia*, Sm., with which species he also places Otto's *M. lanceolata*, described in Hort. Berol. 36. The description thus appearing under *M. genistifolia*, Sm., in the Flora Australiensis, *loc. cit.*, can now be shown to cover three distinct species of Melaleucas, which differ from each other, in morphological, field and chemical characters, and so for the sake of scientific precision should be separated.

Systematic.—A small tree or large shrub, rarely exceeding fifteen feet in height, terminal branchlets and calyx pubescent. Leaves up to one inch long, lanceolate, sessile, rigid or recurved, or slightly concave, acute or acuminate, finely striate, from five to seven or nine nerves, more or less conspicuous in each leaf. Flowers in distinct pairs of interrupted spikes towards the ends of the branchlets, each flower being subtended by two bracts, one a leafy outer bract which latter sometimes remains till after the fruit has matured. Calyx pubescent, tube ovoid, about one line long, lobes triangular, acute. Petals about twice the

length of the lobes of the calyx, very deciduous. Staminal bundles about three lines long, the claws mostly exceeding the petals. Fruit capsule not much enlarged, the acute lobes pronounced.

Habitat.—We have here to acknowledge our indebtedness to Mr. J. H. Maiden, Government Botanist, who very kindly permitted us to examine the material at the Botanic Gardens, where we obtained the following localities:—Mueller's original specimen with autograph locality, Narrabri, N.S.W., J. H. Maiden; Boggabri, N.S.W., R. H. Cambage; Murwillumbah, N.S.W., W. Forsyth; Stroud, N.S.W., A. Rudder; no locality, Dr. Leichhardt. To the above is added our own material from Oakey Creek, Warialda, N.S.W., C. F. Laseron and A. Hamilton; and the Macleay River above Kempsey, C. F. Laseron.

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This species more closely approaches *M. styphelioides* in facies than *M. genistifolia*, especially in leaf characters, but is quite distinct from it in the flowers and other features as stated by Mueller, *loc. cit.* *M. genistifolia* is recorded by its author as having three veined leaves, and in some respects not unlike *M. nodosa*, points that differentiate it from this species. The similarity drawn by Smith probably refers to the disposition of flowers, for *M. genistifolia* like *M. nodosa* has a tendency to globular heads of flowers. It is therefore not clear to us why Bentham confounded *M. bracteata* with *M. genistifolia*. On a cortical classification this tree would stand alone, for as far as our knowledge goes, all other Melaleucas known to us have a thin laminated papery bark, whereas in this one it is hard, compact, checkered, very similar to that of *Monotica ellipitca* of the N.O. Epacrideae. It could well have been given a specific name on bark characters alone. The chemical differences are well marked, as well as the anatomical structure.

Leaf anatomy.—The most characteristic feature in the leaf structure is the preponderance of palisade parenchyma, which approximately occupies more than three-fourths of the leaf substance. The spongy parenchyma is thus limited, and only occupies a small fraction of the median portion, in which also occur the bundles, mostly seven in number, the phloem and xylem in each being also very limited; each bundle is bounded both dorsally and ventrally by a cluster of sclerenchymatous cells. Here and there scattered laterally from these are a few transfusion tissue specimens. Stomata are found on both surfaces, the guard cells being in depressions amongst the epidermal cells, which latter are rectangular with domed outer walls. The interior of these cells contains, attached to the top, a small portion of the manganese compound, the only place where it seems to occur in the leaves of this species. The amount of Mn in the ash of the leaves alone was only 0·005%. The series of sections show that the oil is produced in cavities or glands and not in channels or canals, and is of lysigenous origin.

Essential Oil.—The oil of this species (*M. bracteata*) is of a very remarkable nature, as it does not partake of the character of the oils of the Melaleucas in any degree, and has little resemblance to the "Cajuput Oils." In fact the statement might almost be made, that so far as we are aware, this oil consists of substances foreign to any that have previously been obtained from any species of Melaleuca; also that it does not contain any constituent common to the oils of the members of this group of plants. Cineol is quite absent.

The principal constituent is methyl-eugenol, of which the oil largely consists. Eugenol is also present, together with free cinnamic acid, and a small amount of cinnamic aldehyde. An ester of cinnamic acid is also a constant constituent, the alcohol being very likely cinnamyl, thus the

ester probably consists of styracin (cinnamyl cinnamate) which is common to many plants. No acid of the fatty series could be detected, nor was any low boiling alcohol obtained after saponification.

The crude oil is slightly laevo-rotatory, and this property is entirely due to the presence of about two or three per cent. of laevo-rotatory phellandrene. This terpene, although occurring in so small an amount, could be separated from the bulk of the oil by steam distillation, afterwards recovering the phellandrene from the product by direct distillation. The methyl-eugenol came over with difficulty when steam distilled, thus allowing the separation of the phellandrene to take place with comparative ease.

Three consignments of material were received, collected in the months of March, May and July. Separate collections were made so that the oil might be distilled during the various times of the year, and differences in composition, if any, during the various periods be detected. Only slight differences, however, were shown in the character of the oil of this species at any time. The ester in the May sample was somewhat less in amount than in the others, the July distillate containing the most. The saponification numbers for the three samples were 5·3, 17·1 and 20·8. Although this variation in the amount of ester was shown, yet the character and constituents of the oils were in general agreement. The yield of oil obtainable from the leaves and terminal branchlets is about 1%. It is heavier than water, so that it would be necessary to vary the usual method of commercial distillation as carried out in the preparation of Eucalyptus oils, for instance. It is probable that methyl-eugenol could be obtained from this species of Melaleuca more cheaply and in larger quantity than from any other source. We have shown[1] that the oil

[1] "Research on the Pines of Australia," Sydney, June, 1910, p. 406.

distilled from the timber of "Huon Pine," *Dacrydium Franklini*, is also largely methyl-eugenol, and this has later been confirmed by Schimmel & Co., Semi-annual Report, Oct. 1910. But the scarcity of that tree, its value for joinery work, and the difficulty of preparation for distillation makes its use in this direction, in comparison with the leaves of this Melaleuca, of secondary importance.

Experimental.—The material was collected at Oakey Creek, viâ Warialda, New England, New South Wales, on the 14th March, the 12th May, and the 14th July, 1908. The leaves and terminal branchlets alone were used. In the first instance 181 lbs. of material gave 26 ounces of oil, equal to 0·898%; with the May sample 360 lbs. of material gave 37 ounces of oil, equal to 0·643%; while the third distillation gave 60 ounces of oil from 389 lbs. of material, equal to 0·964%. There was a preponderance of the woody branches in the May material, which accounts mostly for the lower yield. It may thus be considered that when distilled commercially, and the material collected with a minimum amount of woody branchlets, more than one per cent. of oil should be obtained from the leaves of this species of Melaleuca. The oil being heavier than water it naturally accumulates at the bottom of the distilled water in the receptacle, if sufficient time is allowed for the purpose; it can then be separated without difficulty.

The oil when first obtained was of a light amber colour, but it darkened somewhat on keeping in the light, due perhaps to the presence of the phenol. The odour of the oil is pleasant and somewhat aromatic, with a strong resemblance to that of methyl-eugenol, and with an indication of cloves later. The general results with the three samples of crude oil were as follows:—

Sample.	Specific gravity.	Rotation, a_D	Refractive index n_D at 20° C.	Saponification number	Solubility in alcohol by weight.
March	1·036 at 18°C.	too dark	1·5325	17·1, free acid 1·2	0·8 vol. 70%
May	1·032 at 18°C.	− 3·1°	1·535	5·3, free acid 0·7	0·8 vol. 70%
July	1·0358 at 19°C	− 1·4°	1·5335	20·8, free acid 1·26	0·7 vol. 70%

It is worthy of remark how closely the refractive indices of the three samples of the crude oil agree, and this is also the case with their specific gravities; the lower figure of the May sample is perhaps indicative of a high specific gravity for the ester, as well as of the presence of a slightly larger amount of phellandrene, also suggested by the higher rotation.

The Phenol.—200 cc. of the March distillate were agitated with a 5% solution of NaOH, until the phenol and free acid were removed. The aqueous portion, with washings, was then treated with ether to remove adhering oil, the ether dispelled by heating, and the solution acidified. The phenol and acid thus separated were removed by ether, and when this had evaporated the residue became crystalline, due to the presence of the free acid. It was again dissolved in ether, the ethereal solution agitated with an aqueous solution of carbonate of soda, in which the acid readily dissolved, leaving the phenol in the ether. The aqueous portion was washed with fresh ether, and the ethereal solutions evaporated to dryness. The phenol weighed 0·7416 gram., equal to 0·36%. It was a dark coloured liquid, and had a marked clove odour. When dissolved in alcohol the blue colour reaction for eugenol with ferric chloride was not at all distinctive, the colour being rather an intense green to bluish-green. This coloration suggested the presence of the isomeric form, chavibetol,

rather than eugenol, but the benzoyl derivative, prepared with benzoyl chloride, when purified from dilute alcohol, melted at 68 – 69° C., thus showing the phenol to be eugenol.

The Free Acid.—The sodium carbonate solution from the phenol was acidified, when a quantity of a substance separated which soon became solid. It was filtered off, washed, boiled with water, and filtered through cotton wool. On cooling, a crystalline acid separated, which was again crystallised from boiling water. It melted at 133° C., and when treated with an aqueous solution of potassium permanganate, the odour of benzaldehyde was instantly obtained. It was thus cinnamic acid, and identical with the acid of the ester. The saponification number for the free acid in this sample was 1·2, so that the free cinnamic acid present in the oil was 0·33%. No other acid occurring in a free state was detected.

The Aldehyde.—The oil from 200 cc. of the March collecting, after removal of the phenol and free acid, was well washed, and agitated repeatedly with a saturated solution of sodium bisulphite for some hours. A very small amount of a crystalline compound was eventually formed, which was separated, dried, decomposed with alkali, and the aldehyde removed with ether. On evaporating the ethereal solution a small quantity of an oil with a cinnamon like odour remained, which on treating with a 10% solution of potassium permanganate eventually gave the odour of benzaldehyde. The amount was too small to allow further tests to be made, but the above results are sufficient to show that cinnamic aldehyde was present in the oil of this species of Melaleuca.

The Free Alcohol.—A portion of the saponified oil of the July sample was boiled with acetic anhydride and anhydrous sodium acetate in the usual way. It was well washed and rendered quite neutral. 3·0766 gram of this acetylated oil,

boiled with alcoholic potash, required 0·0756 gram KOH, representing a saponification number 24·57. As the ester originally present in the oil gave S.N. 19·54, (20·8 – 1·26), the ester formed by the free acid had a saponification number 5·03 representing 1·2% of free alcohol if calculated as cinnamyl. No indication of methyl or other low boiling alcohol could be detected when the products of saponification were distilled.

The Phellandrene.—The crude oil was always slightly laevo-rotatory, but no low boiling terpene could be well separated by direct distillation. However, by steam distilling the saponified oil, it was possible to recover the small quantity of the terpene to which the activity of the crude oil is due. The saponified oil from 200 cc. of the March distillate was rapidly steam distilled for about one hour, by which time 13 cc. had come over; it contained much methyl-eugenol, shown by oxidising to veratric acid and other tests, but practically the whole of the active terpene had distilled, the distillate being laevo-rotatory a_D – 6°. The bulk oil remaining in the flask was inactive to light. Cineol could not be detected in this portion.

The oil which came over with the steam was then directly distilled, it commenced to distil at 173° C., and by 185° C. 3 cc. had been obtained. This fraction was colourless, mobile and had a terpene odour. The specific gravity at 21° C. was 0·8965; the rotation a_D – 14·7°; and the refractive index at 20° C. = 1·483. The colour reaction for sylvestrene and carvestrene was not given. The refractive index, together with the boiling point suggested phellandrene, and when the oil was treated with nitrous acid in the ordinary way, it soon became quite solid. The solid mass was placed on a porous plate, and the white crystalline nitrite afterwards purified from chloroform by precipitating with alcohol. The crystals melted at 120° C. This is a

slightly higher temperature than usual, although Schreiner (Pharm. Arch. 4. 90) shows that phellandrene nitrite melts at 120 – 121° C.

The active terpene in the oil of this species of Melaleuca is thus laevo-rotatory phellandrene, a most unusual constituent in the oils of this genus. To confirm the above results 100 cc. of the oil of the May collection were steam distilled, 12 cc. being obtained. This oil was then directly distilled when 3·5 cc. came over between 173 and 200° C. This was laevo-rotatory a_D – 13·9°, and gave the phellandrene reaction strongly.

The Ester.—After removal of the free acid, the phenol and the aldehyde, the oil was boiled for two hours with an aqueous solution of caustic soda, under a reflex condenser. The aqueous portion was separated, filtered and acidified, when a considerable quantity of a solid acid was obtained; this acid was purified by repeatedly crystallising from boiling water. It was sparingly soluble in cold water, somewhat readily in boiling water, and was soluble in alcohol and in ether. The cold aqueous solution readily discoloured a very dilute solution of potassium permanganate, thus indicating an unsaturated acid. The crystals melted at 133° C., and when treated with a strong aqueous solution of potassium permanganate, developed at once the odour of benzaldehyde. When 0·1264 gram of the acid was dissolved in excess and titrated back, it was found to have neutralised 8·5 cc. decinormal NaOH, thus indicating a molecular weight 148. $C_9H_8O_2$ = 148.

The above results show cinnamic acid to be the acid of the ester in the oil of this species of Melaleuca, agreeing in this respect with the free acid. The aqueous portion separated from the cinnamic acid was distilled, but no indications for a volatile acid were obtained, so that acetic acid does not occur. The identity of the alcohol of the ester is

not certain, but the indications point to it being cinnamyl alcohol. It certainly boils at a high temperature, and no low boiling alcohol could be detected in the products of saponification. The presence of both cinnamic acid and cinnamic aldehyde might suggest the occurrence also of the corresponding alcohol. On oxidising the third fraction the principal acid formed was veratric acid, from the methyl-eugenol, but it also contained an acid of lower molecular weight and of lower melting point, which gave indications for benzoic acid. 0·1102 gram acid dissolved in decinormal NaOH and titrated back had required 6·3 cc. $\frac{N}{10}$ NaOH, indicating a molecular weight of 175. The molecular weight of veratric acid is 182. The melting point of the purified acid from this fraction was some few degrees lower than that of the veratric acid from the second fraction. The complete identity of the alcohol of the ester thus remains for the present in abeyance.

The Methyl-eugenol.—175 cc. of the crude oil of the July sample were boiled for two hours with an aqueous solution of soda under a reflex condenser. The aqueous portion was acidified, and the cinnamic acid recovered as described with the March oil. The saponified oil was washed, dried and filtered. It was lemon-yellow in colour, and had an odour more aromatic than crude oil, with a strong resemblance to that of methyl-eugenol. Its specific gravity at 18° C. = 1·0349; rotation a_D − 1·6°; refractive index at 20° C. = 1·5325; and was soluble in 0·7 volume of 70% alcohol. 100 cc. were distilled, but only 3 cc. came over below 243° C., this was separated. Between 243 and 250° C. no less than 73 cc. distilled, and 76 cc. below 252°; this was separated as second fraction. Between 253 and 258° C. 15% came over as third fraction. The distillation was thus fairly constant, and no less than 65% distilled between 248 and 252° C. Nothing came over below 220°, so that it was

not possible to separate the phellandrene at its ordinary boiling point by direct distillation. The somewhat regular distillation of the saponified oil is due to aqueous alkali being used, because a sample of the oil saponified by alcoholic potash did not boil so regularly, and mostly distilled at a higher temperature. This was evidently due to the partial alteration of the side chain from the allyl to the propenyl group, brought about by the boiling alcoholic potash.

The specific gravity of the second fraction was 1·0368 at $\frac{20°}{15}$ C., the refractive index at 20° C. = 1·5325; and the rotation a_D — 0·15°. The specific gravity of the third fraction at 20° C. = 1·039; the refractive index at 20° C. = 1·5355; and it was inactive to light. These results do not indicate the presence of a sesquiterpene in any quantity, but rather that the constituent of the third fraction is also largely methyl-eugenol, similar to the second fraction, and this is confirmed by the formation of veratric acid in quantity, on oxidising it with potassium permanganate.

That the bulk of the oil from this Melaleuca is methyl-eugenol is shown from the result of a methyoxy determination carried out by Zeisel's method. 0·2622 gram of the July oil gave 0·4844 gram AgI, corresponding to 24·38% OCH_3, which represents 70% of methyl-eugenol. To prove the identity of the methyl-eugenol both the characteristic bromide and the veratric acid were prepared. The bromide was obtained by dissolving the oil in carbon tetrachloride and adding bromine to end reaction. The solvent was then evaporated, a thick mass being left which eventually crystallised. This was then purified by repeatedly recrystallising from alcohol. The beautiful needle crystals melted at 77 – 78° C. A determination of the bromine showed that 0·488 gram contained 0·2786 Br = 57·09%. $C_6H_2Br(OCH_3)_2C_3H_5Br_2$ contains 57·55% bromine. The crystalline bromide was thus the tribromide of methyl-eugenol.

For the preparation of the veratric acid six grams of the oil were treated with a neutral solution of potassium permanganate, the oxidation being completed in an acid solution. When cold, the product was extracted with ether, the ether distilled off, the residue treated with dilute soda, filtered, acidified, the crystalline acid separated and purified by repeatedly recrystallising from hot alcohol. The crystals melted at 178 – 179° C.; they were slightly soluble in water, readily in ether, but less readily in cold alcohol. 0·1926 gram dissolved in excess of decinormal soda, and titrated back, had required 10·6 cc. $\frac{N}{10}$ NaOH for neutralisation, representing a molecular weight 181·7, $C_9H_{10}O_4$ = 182. These results show this acid to be veratric acid. The principal constituent in the leaf oil of this species of Melaleuca is, from the foregoing results, shown to be methyleugenol (allyl veratrol) $C_6H_3 \cdot C_3H_5$ (1) $\cdot OCH_3$ (3) $\cdot OCH_3$ (4) and that the odour of the oil is mainly due to that substance.

(3) *M. styphelioides*, Sm., in Trans. Linn. Soc. III, p. 275.

Botany.—Bentham in his Flora Australiensis, Vol. III, p. 144, gives a good description of this Tea Tree, so with that of the original there is no need to reproduce one here. The material examined by us agrees in every respect with what both these authors say concerning it. It appears to be constant in characters throughout its wide geographical distribution.

Chemistry.—Only traces of an essential oil can be obtained from the leaves of this species by steam distillation. 128 lbs. of leaves and branchlets collected at Belmore, near Sydney, in June 1907, were distilled for some hours, but only a bare film of oil was noticed on the surface of the water in the receiver, and this could not be collected. To be more certain on this point other material was obtained from Belmore in April, 1908. This was also steam distilled for

some hours; all the distilled water was collected to determine whether it contained an oil heavier than water, but with negative results. Not sufficient oil distilled to be separated, so that this species of Melaleuca has no commercial value in this direction.

ACKNOWLEDGEMENTS.

We wish to acknowledge the assistance we have received from the following gentlemen:—Mr. J. H. Maiden, Government Botanist and Director, Botanic Gardens, Sydney; Professor A. J. Ewart, Government Botanist, Melbourne; Mr. T. D. Ferguson, Gladstone, Queensland; Mr. F. Hamilton, Oakey Creek, Warialda, New South Wales; and Mr. F. H. Taylor, of the Technological Museum, for cutting sections of the leaves.

EXPLANATION OF PLATES, XLI TO XLVIII.

M. trichostachya.

Fig. 1 (Coloured). Transverse section through half the width of a leaf. Four oil glands are fully sectioned, and another towards the extreme right is only just in the plane of the knife's edge; guard cells are seen on both dorsal and ventral surfaces. The central bundle is on the extreme left. The brown patches in the central spongy mesophyll mark the manganese compound present in that tissue. × 124. Stained with hæmatoxylin and safranin.

" 2. Transverse section of a leaf cut clear of any oil gland. × 93.

" 3. Transverse section through centre of a leaf, but excluding the edges. The central bundle of the figure denotes the midrib. × 155.

" 4. A magnification through a bundle, showing sclerenchymatous cells bounding the phloem (staining black) the xylem succeeding it towards the bottom. On the right top of the section are some cells of the palisade parenchyma. × 630.

M. bracteata.

Fig. 5. Transverse section through leaf showing seven bundles through the median mesophyll tissue, and two oil glands in the left half. × 93.

„ 6 Transverse section through the outer portion of a leaf, the bundles being more distinctly seen than in Fig. 5. Stomata are more numerous on the lower surface of the section and denoted by the depressions with guard cells at the bottom. × 155.

„ 7. A magnification towards the edge of a leaf, having four bundles and two oil glands in the field of vision. Stomata can be traced on both surfaces of the leaf. × 155.

„ 8. Transverse section through midrib or central vascular bundle of a leaf. Sclerenchymatous cells are seen to band it on both ventral and dorsal sides. The xylem vessels are few, the phloem being indicated by the black patch, only a single row of spongy mesophyll separates the palissade layers (top and bottom of plate). × 630.

„ 9. Transverse section through a bundle of a leaf and surrounding tissue. Just above the bundle and touching the left edge of the circle are two rectangular cells of the transfusion tissue, and five cells between these again towards the right is another. On the top of the picture are two guard cells. × 378.

„ 10. A longitudinal section of a leaf showing three lysigenous oil glands near the top surface and a bundle in the left half. × 155.

„ 11. Longitudinal section through the median bundle and its adjacent leaf tissue. The xylem and phloem run through the centre being bounded top and bottom by sclerenchymatous vessels (showing fainter than the above). The palissade parenchyma has its long walls at right angles to these, which are succeeded by the epidermal cells. × 378.

Plate XLVII—*Melaleuca trichostachya*, F.v.M.

Fig. 1. Terminal branchlets with flowers and buds (nat. size).
„ 2. Branchlet with fruits (nat. size).
„ 3. Individual leaf (enlarged).
„ 4. Individual flower (enlarged).
„ 5. Individual bundle of stamens (enlarged).

Plate XLVIII—*Melaleuca bracteata.*

Fig. 1. Terminal branchlets with flowers (natural size).
„ 2. Branchlet with fruit (natural size).
„ 3. Individual flower (enlarged).
„ 4. Individual petal (enlarged).
„ 5. Individual bundle of stamens (enlarged).

NOTES ON SOME FOSSIL PLANTS FROM THE ROOF OF THE COAL SEAM IN THE SYDNEY HARBOUR COLLIERY.

By W. S. Dun.

[Communicated by permission of the Under Secretary for Mines.)

With Plates XLIX, L, LI.

[*Read before the Royal Society of N. S. Wales, December 7, 1910.*]

The specimens discussed in this note were collected by Mr. Hill, and brought under my notice by Mr. C. A. Süssmilch, F.G.S., Lecturer in Geology, Technical College, Sydney. As is well known, the Bulli or Upper Coal Measures of Permo-Carboniferous age under Sydney are overlaid by the shales, sandstones, and grits of the Narrabeen stage of Triassic age, and it has been the custom to consider the Bulli (Wallarah) Coal Seam as the closing phase of Permo-Carboniferous sedimentation and the last appearance of the Glossopteris Flora.

From the workings of the Sydney Harbour Colliery no evidence of any break in the sedimentation is observable, there is a direct conformity of the overlying shales to the seam, and there is every reason to consider that in this portion of the basin there is a direct succession, with passage beds, between the Permo-Carboniferous and the Narrabeen Stage of the Hawkesbury System.

General sections of the strata passed through in the shaft have already been published,[1] and certain fossils have also been described from the shales forming the roof of the seam.[2] It is noteworthy that a *Schizoneura* (*S. australis* Eth. fil. = *gondwanensis*, Feistm.) is particularly abundant and that this Equisetal had previously been described from the roof of the Bulli Seam at Bulli.[3]

The first appearance of *Schizoneura* was at about ten feet above the coal seam, and *Glossopteris browniana* was associated with it about five feet above the seam. At higher levels in the shaft plants of Mesozoic (Narrabeen) affinities were met with, but their occurrence was rare until we get to the 1,300 feet level when the *Thinnfeldia* type of vegetation becomes abundantly developed; and *Estheria* was met with at 1,771 feet and 2,350 feet.

Recently additional fossils have been found in the roof shales and these appear to be of particular interest:—

1. Cladophlebis cf. Roylei, Arber. (*Plate 49.*)

An alethopterid fern apparently very closely related to *Cladophelbis Roylei*, Arber, is particularly abundant. Unfortunately no specimens of *C. Roylei* are available for comparison, but there appears to be little doubt that our

[1] Journ. Roy. Soc. N.S.W., xxxiii, p. 211-219; Ann. Rept. Dept. Mines, N. S. Wales for 1907, pp. 154-161.

[2] Etheridge, Rec. Geol. Surv. N.S.W., 1903, vii, pp. 234, 235, pls. 48, 49; Dun, W. S., Proc. Linn. Soc. N.S.W., Vol. xxxvi, 1901, p. 738; Aber, E. A. N., Glossopteris Flora, 1905, p. 5.

[3] Etheridge, *op. cit.*, 1893, p. 74-76, pl. 13.

specimens belong to the same group. In common with the Indian species, the frond is bipinnate, the pinnular attachment is similar, the pinnules have a tendency to become more obliquely inclined, margins sinuate or entire, never denticulate. There is also a tendency in this fern for the pinnules to be more closely set than in typical *C. Roylei*,[1] The venation is very close to that of *C. Roylei*, but the median nerve is relatively strong, secondaries acute, frequently forking twice.

The Indian species is that originally described as *Pecopteris Lindleyana*, Royle, and removed to *Alethopteris* by Schimper and Feistmantel. *Alethopteris Lindleyana* (?) has been described from Mount Esk in Queensland (Lower Mesozoic) by Mr. Etheridge.[2] As will be seen by the figure in the Queensland form, the pinnules are more elongate and more acute than our species, and I have little doubt that the two forms will be found to be different, on the examination of larger series. Mr. Shirley's species from Denmark Hill, Ipswich Coal Measures (Jurassic), is also apparently different.

In India *Cladophlebis Roylei* is directly associated with the Lower Gondwana Glossopteris Flora and also with *Schizoneura gondwanensis*, Feistm. It occurs in the Raniganj Group, the upper portion of the Damudas. In New South Wales no fossils of this type have been to the present recorded from the Newcastle or Upper Coal Measures, but I have recently seen a similar fern from the Permo-Carboniferous Coal Measures of the Dawson River, Queensland.

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[1] For description and synonymy see Arber, Glossopteris Flora, p. 142, *et seq.*

[2] Geol. Pal. Q'land., 1892, p. 370, t. 17, f. 3, 4.

[3] Bull. Geol. Surv., Q'land., 1898, No. 7, p. 20, t. 13, f. 1.

2. SCHIZONEURA. (*Plate 50.*)

This specimen is taken to represent the upper portion of a stem of *Schizoneura gondwanensis* (*australis*), showing seven areas of leaf attachment, the leaf-sheaths being split into numerous linear segments. This may be compared to Feistmantel's figure, though in our case the specimen is more delicate and of smaller proportions. From the abundance of large Equisetaceous stems in these shales it is clear that the Australian *Schizoneura* attained to as great a size as the Indian, although no perfect specimens have been found as yet.

A large stem showing two nodes is figured (*Plate 51*). It is impossible in the absence of foliage to separate the stems of *Phllotheca* and *Schizoneura*, but from the association there appears to be no doubt about the reference. So far as I am aware no *Phyllotheca* has been collected from these beds yet.

3. RHIPIDOPSIS GINKGOIDES, Schmalhausen (?) var. SUSSMILCHI, nov. (*Plate 51*).

The leaves referred to this species are represented by two imperfect specimens shown on *Plate 51.* One of these shows the leaf divided into three main segments, very wedge-shaped, tapering markedly towards the point of attachment; two of these segments show accentuated lobation in themselves. The point of attachment to the stem or stalk is not preserved. The venation is extremely fine, dichotomous several times, and in its degree of development more like that of one of the *Ginkgos* than *Noeggerathiopsis.* The terminations of the lobes are rounded. There is room for considerable doubt as to whether this can be regarded as a *Ginkgo* or as belonging to such a type as *Noeggerathiopsis*,[1] but though this latter genus may adopt a palmate habit as figured by Dana, still so far as the Aus-

[1] For general characters see Arber, *op. cit.*, pp. 178 – 190.

tralian forms are known, lobed and ovate leaves have not been met with.

The degree of variation admitted in leaves of the Ginkgoales is great, and comparison may be made with such species as *G. digitata*, Brongniart, from the Jurassic as figured by Seward,[1] or to *Baiera Phillipsi*, Nathorst.[2] From these figures it will be noticed that the degree of dissection of the leaf of *Ginkgo* is very variable, in fact it has been noted that it is hard to distinguish between *Ginkgo* and *Baiera*.[3] It is suggested that this form be regarded as a local variation of *Rhipidopsis ginkgoides*.[4] Our variety is intermediate in size between Feistmantel's Indian types[5] and Schmalhausen's.[6]

The specimens are too imperfect to enable one to say whether the lower leaflets are a size relative to those in the type specimens, and as that form is an essential character of *Rhipidopsis*, the doubt attached to the determination is very evident. In India *Rhipidopsis ginkgoides* occurs in the Barakar Group of the Damudas and in Argentina associated with the Glossopteris Flora at Bajo de Velis.[7] Schmalhausen's Jurassic beds of the Petschora already referred to are now regarded as Permian.

1 Seward, The Jurassic Flora, Yorkshire, pt. 1, 1900, t. 9, f. 2, 10.

2 Seward, *op. cit.*, t. 9, f. 4.

3 Seward, Fossil Floras Cape Colony, Ann. S. African Museum, 1903, IV, p. 65.

4 For general discussion and synonymy see Arber, Glossopteris Flora, p. 211.

5 Flora Gondwana System, Pal. Ind., 1886, p. 43, t. 3 A, f. 1, 2.

6 Beitr. z. Jura Flor. Russlands, Mem. Acad. Imp. Sci., St. Petersbueg 1879, XXVII, t. 6, f. 1, t. 8, f. 3 – 12.

7 Arber, *op. cit.*, p. LXXI; for general discussion see Zeiller, Bull. Soc. Geol. France, 1896, XXIV (3), p. 466.

8 Zeiller, *op. cit.* p 469.

SAND BLAST TESTS OF NEW SOUTH WALES TIMBERS.

By Prof. W. H. WARREN, M. Inst. C.E., Wh. Sc.

With Plates LII, LIII, LIV, LV, LVI.

[*Read before the Royal Society of N. S. Wales, December 7, 1910.*]

THESE tests were carried out by Professor Warren and Mr. J. MacD. Royle, B.E., with a view to obtaining the relative values of timbers for wood-blocking, flooring and similar purposes. It is very difficult to get a suitable test for these properties of materials, but of all tests so far devised the sand blast method appears to be the best, as the material in this method is actually worn away by abrasion. It is possible to block, for instance, different parts of the same street with different timbers, but experiments like these would necessarily last several years in order to obtain results of any value as far as the resistance to wear of the various timbers is concerned, and even then it would be most difficult to say that the different kinds of timbers had been subjected to the same conditions.

Description of the Apparatus.

A general view of the sand blast apparatus is shown in (*Plate 52*) and a diagramatic view in (*Plate 53*). The apparatus consists essentially of a nozzle through which sand can be propelled at a high velocity by means of a jet of steam. This is carried out in the following manner:—Steam from the boiler (not shown) enters the cylinder *a* at *b* (*Plate 53*). Part of this steam flows straight to c where it exhausts to the atmosphere through a nozzle, thus causing a partial vacuum around *c*. The remainder flows up through a valve at *d*, tray *e* and nozzle *f* to the expanding nozzle *g*, where it gets completely dried and superheated. The sand

is contained in the reservoir α from which it trickles down through the opening *i* and nozzle *j* on to the tray *e*. The jet of steam rushing with velocity through *e* causes a partial vacuum, so that the sand which has fallen on *e* enters through the small aperture *k*, and is caught up by the jet of steam which carries it upwards and projects it against the specimen *l*. After impact with *i* the heavier portions of the sand fall downwards into *h*, from which it may be removed from time to time. The exhaust jet *c* already mentioned, produces a partial vacuum, and in the manner indicated by the arrows, causes the exhaust steam and dust in chamber *m* to rush down through *n* into *o* and *q*, from which it escapes to the atmosphere at *c*. By means of *r* we can shut off the jet of steam and sand from the specimen. The flow of sand through the pipe *i* is regulated by perforated ring *j* partially rotated by means of a lever *s*, so that the orifices at *j* may be opened or closed as desired. The specimen *l* is held in place by a screw *u* which presses the plate *t* against it. The specimen is rotated about its own axis and by means of an epicyclic wheel train *w* the axis itself rotates along the circumference of a circle.

We thus see that every part of the exposed surface of the specimen is subjected to the action of the jet, thus assuring a uniform rate of abrasion over the exposed part of the specimen. *x* is a pressure gauge marked in kilogrammes per square millimetre. At the back of the apparatus we have a door *z* which is opened for cleaning the machine. *y* is a rubber ring to make a tight joint. A constant pressure of 3 dgm. per sq. mm. which is equivalent to 42·6 lbs. per square inch was used throughout the tests.

In order that each particle of sand may strike the specimen once only and not be used again, two feeding devices α α have been arranged to allow the fresh sand to flow through *i* and *j* on to the tray *e*. The used sand accumulated

in the receiver *h* is removed about every three hours. As in all hardness tests there is no absolute standard; we have no unit for expressing the resistance to abrasion except by comparing the relative behaviour of materials tested under similar conditions. If we decide upon some material as a standard, then it is possible to give the hardness of other materials as a ratio of the hardness of the standard in the same way as the specific gravity of a material is expressed in regard to that of water as a standard. We therefore have to decide on some material to be used as a standard for hardness. For this purpose North Coast Blackbutt has been decided upon, and the hardness of all the other timbers are given in terms of this standard.

As in "the holding power of nails and dog-spikes" and in the Brinell Ball Test, there are three different directions in which the timber can be tested namely, those marked *a*, *b*, *c*, in Fig. 1.

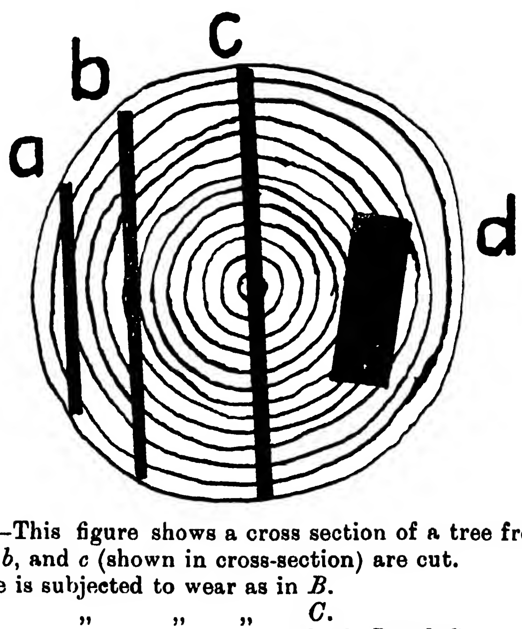


Fig. 1—This figure shows a cross section of a tree from which boards *a*, *b*, and *c* (shown in cross-section) are cut.
a in use is subjected to wear as in *B*.
b " " " " *C*.
c " " " " both *B* and *C*.
d shows a wood block.

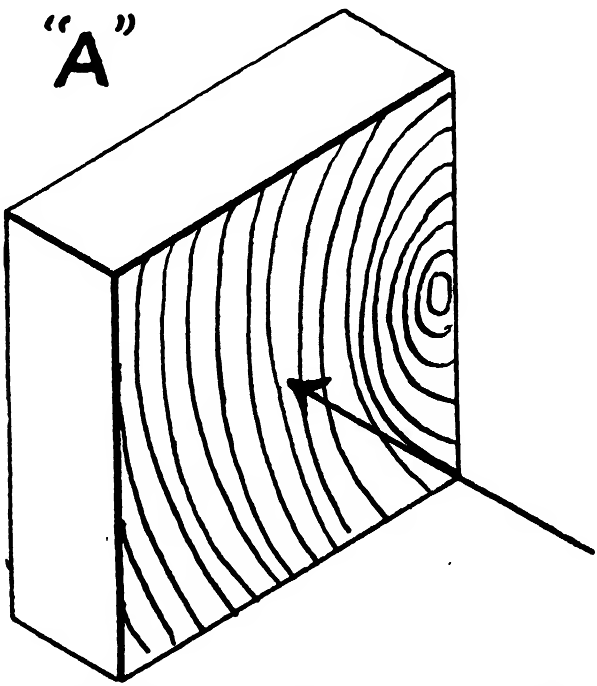
We have picked on *c* (*i.e.*, tangential to the annual rings) as that direction in which we test the timber for the standard determination of the resistance to abrasion. The sand used in these tests was supplied by the Emu Plains Road Metal and Gravel Company, and has all been passed through a sieve of 900 meshes to the square inch. The specimens are all cut to a size $3'' \times 3'' \times 1''$, and are weighed to the nearest grain before being subjected to the test.

When the tests are over, the specimens are immediately weighed again and the loss of weight noted. It is necessary that the weighing should be done not long before, and soon as possible after the test, as, owing to the hygroscopic properties of the timber, we are likely to get a change in weight on account of the timber absorbing or giving off moisture. Having noted the weight thus abraded, we must divide by the weight per cubic inch of the timber which will give us the volume in cubic inches abraded. We multiply this by a constant ($10^3 = 1000$) so as to bring the result to a convenient size, and we can follow the same procedure for each timber thus obtaining a series of numbers. We could write the numbers down as the hardness numbers of the various timbers, provided that the conditions of testing were always the same.

The greatest discrepancy in the constancy of the conditions is likely to occur in the case of the sand as we cannot always be certain of getting sand of the same quality. It might, for example, contain more quartz particles or be less finely divided than the last lot, which would tend to greatly alter the results of the two series, though each timber in either series would be perfectly comparable with any other timber in that series of tests. And so we can by using a piece of the standard timber in each series of tests reduce both series to a common basis and compare them one with the other, irrespective of what the con-

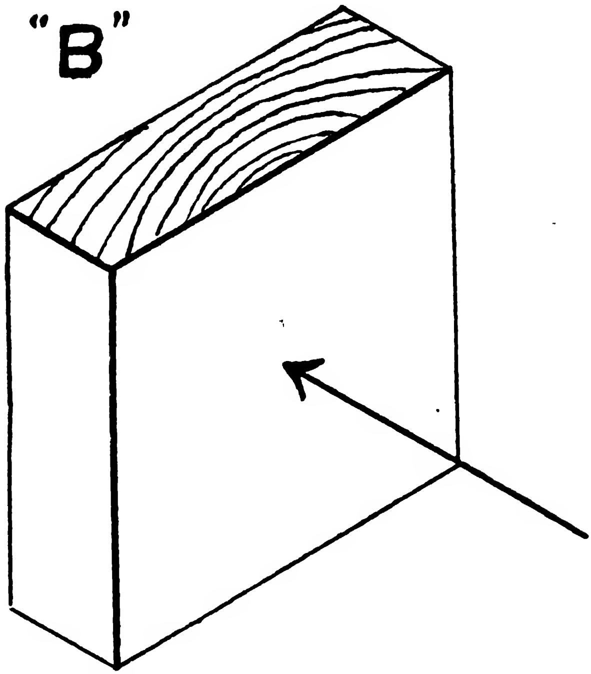
ditions were in each series, provided of course, that those conditions were kept constant throughout the series.

The test for the standard timber is two minutes under a steam pressure of 42·6 lbs. per square inch. In the case of tests on the end of the grain, in order to decrease the likelihood of error in weighing the very small amount which would be abraded in two minutes, we increase the time to say three or five minutes. This we can easily reduce to two minutes by multiplying the result $\frac{2}{3}$ or $\frac{2}{5}$ as the case may be. In the tests carried out six specimens of each timber were tested; two as in *a* (fig. 1); two as in *b*, and two as in *c*, *i.e.*, A.—parallel to direction of fibre; B.—perpendicular to direction of fibre, and also perpendicular to annual rings; C.—perpendicular to direction of fibre, and also tangential to annual rings.



A.—Tested in a direction parallel to the fibre, as used in street paving.

"B"



B.—Tested in a direction perpendicular to the annual rings and also to fibre, as used in flooring boards.

Since the harder the timber is, the less the amount abraded, we get a large number for a soft timber and a small number for a hard timber.

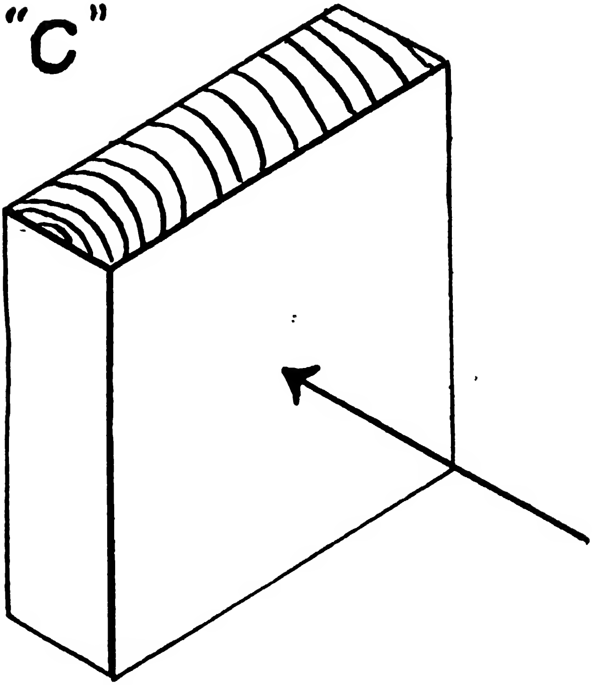
The results of the test are shown in Table I. In this table the columns marked "Number" simply give the number of the timber and the number of the specimen of that timber, 1 and 2 being for direction of blast C

3 and 4 ,, ,, ,, B

5 and 6 ,, ,, ,, A.

The third, eighth and eleventh columns give the weights abraded in the three directions of test. The fourth column is the weight per cubic foot. The fifth column gives the volume abraded $\frac{\text{weight abraded}}{\text{weight per cubic inch}}$ and multiplied by 10^3 to make

"C"



C.—Tested in a direction tangential to annual rings and perpendicular to fibre.

the number a convenient size. In testing the standard we get 118 under the fifth column, and so we must multiply all results by $\frac{100}{118}$ to reduce them to a common basis so that they can be compared with any other series of tests. The rest of the table needs no remark, except, perhaps, the last column, where the hardness in the three directions are given relatively to each other.

In Table II we have the timbers given with their various hardness in the three different directions. From this table Table III is made up, which just gives the timbers arranged in order of hardness in the three directions, C, B and A. If we add the three numbers which represent their positions in descending order in each table, we can find their order

TABLE I.—NEW SOUTH WALES TIMBERS—SAND BLAST TESTS.

Local Name.	No.	C Weight abraded grains.	C Weight per cub foot.	C Volume abraded × 10^3	C Volume reduced to standard.	No.	B Weight abraded grains	B Volume abraded × 10^3	B Volume reduced to standard.	No	A Weight abraded grains.	Time in minutes.	Weight reduced to two minutes	Volume reduced × 10^3	Volume reduced to standard	Ratio of hardness in three directions: A : B : C
Blackbutt, N.C.	1_1	29·5	59 6	124		1_3	12·5	52	44	1_5	11	3	7·3	30	25	
	1_2	27		112		1_4	24·5	101	86	1_6	18	5	7·2	30	25	-
				mean												
				118	100	$1_4{}^1$	28	116	98							1 ; 3 : 47
Tallow Wood, N.C.	2_1	47·5	71·4	164	139	2_3	37·5	130	110	2_5	15	3	10	35·0	30	
	2_2	52		180	167	2_4	31·5	109	92	2_6	17·5	5	7	24	20	
						$2_4{}^1$	36	125	106							1 : 4 : 6
Grey Gum, N.C.	3_1	43	75·7	140	119	3_3	22	72	61	3_5	25	5	10	33	28	
	3_2	43		140	119	3_4	26	85	72	3_6	11	3	7·3	34	20	1 : 27 : 5
Grey Ironbark, N.C.	4_1	28	71·4	97	82	4_3	16·5	57	48	4_5	8	3	5·3	18	15	
	4_2	25		86	73	4_4	21·5	74	63	4_6	13 5	5	5·4	19	16	1 : 35 : 5
Blue Gum, N.C.	9_1	47	62·1	187	157	6_3	13·5	54	46	6_5	20	5	8	32	27	
	6_2	45		178	151	6_4	19·5	77	65	6_6	9	3	6	24	20	1 : 24 : 6·5
Brush Box, N.C	7_1	29	61·7	116	98	7_3	9 5	37	31	7_5	1·74	5	7	28	24	
	7_2	26		104	88	7_4	15·5	62	53	7_6	1·44	5	5·8	23	19	1 . 2 : 44
Turpentine, N.C.	8_1	21	63·1	82	69	8_3	11·5	45	38	8_5	14	3	9·3	36	30	
	8_2	16		63	53	8_4	11	43	36	8_6	11	3	7·3	29	25	1 : 1·4 : 2·4
Red Mahogany, N.C	9_1	47·5	63·1	185	157	9_3	33	129	109	9_5	12	3	8	31	36	
	9_2	39 5		154	130	9_4	19·5	76	64	9_6	9	3	6	23	19	1 : 3·1 : 5·7
White Mahogany.	10_1	30·5	68·2	110	93	10_3	23	84	71	10_5	25	3	sand	wet—	neg	lect test:
N.C.	10_2	32		116	98	10_4	17·5	64	54	10_6	13	3	8·6	31	26	1 : 2 : 3·8
Colonial Teak, N.C.	11_1	27	59·3	112	95	11_3	44·5	185	157	11_5	19	3	12·6	52	44	
	11_2	27		112	95	11_4	21·5	90	76	11_6	19	3	12·6	52	44	1 : 2·6 : 2·2
Grey Box, S.C.	12_1	31·5	73·9	101	86	12_3	16·5	55	47	12_5	12	3	8	26	21	
	12_2	23·5		79	66	12_4	14	47	40	12_6	12	3	8	26	21	1 : 2 : 3 5
Woolly Butt, S.C.	13_1	23	70	78	65	13_3	9·5	32	37	13_5	12	3	8	27	23	
	13_2	17·5		59	50	13_4	9	30	35	13_6	10	3	6·6	22	19	1 : 1·7 : 2·7
Spotted Gum, S.C.	14_1	13	7·1	45	38	14_3	22	76	64	14_5	11	3	7·3	25	21	
	14_2	21·5		75	64	14_4	8	28	24	14_6	11 5	3	7·6	26	22	1 : 2 0 : 2·4
Turpentine, S.C.	15_1	20	64·8	76	64	15_3	9	34	29	15_5	8	3	5·3	20	17	
	15_2	26		100	85	15_4	15	57	47	15_6	12	3	8	30	25	1 : 1·8 : 3·5
Blackbutt, S.C.	16_1	22	69	79	67	16_3	18·5	66	56	16_5	9	3	6	21	18	
	16_2	27		97	82	16_4	16·5	59	50	16_6	12·5	3	8·3	30	25	1 : 2·4 : 3·5
Stringy Bark, S.C.	18_1	26·5	66·6	98	83	18_3	11·5	43	36	18_5	14	3	9·3	34	29	
	18_2	26		96	81	18_4	10	37	31	18_6	13	3	8·6	35	30	1 : 1·1 : 2 8

of combined hardness in the three directions. As an example take Blackbutt N.C. in Table III; it comes twelfth in column C, thirteenth in column B, and tenth in column A. Now adding these, we get the number 35. If we treat each timber similarly we get numbers as shown in Table IV. Now arranging these in descending order of hardness we get Table V.

Table II.—Mean Hardness Numbers.

	Name.	No.	C	B	A
North Coast.	Blackbutt	1	100	76	25
	Tallow Wood	2	153	103	25
	Grey Gum	3	119	66·5	24
	Grey Ironbark ...	4	77·5	55·5	15·5
	Blue Gum	6	154	55·5	23·5
	Brush Box	7	93	42	21·5
	Turpentine	8	61	37	27·5
	Red Mahogany ...	9	143·5	86·5	27·5
	White Mahogany ...	10	95·5	62·5	26
	Colonial Teak... ...	11	95	116	44
South Coast.	Grey Box	12	76	43·5	21
	Woolly Butt	13	57·5	36	21
	Spotted Gum	14	51	44	21·5
	Turpentine	15	74·5	38	21
	Blackbutt	16	74·5	53	21·5
	Stringy Bark... ...	18	82	33·5	29·5

TABLE III.

Order.	C	B	A
1	Spotted Gum, S.C.	Stringy Bark, S.C.	Grey Ironbark, N.C.
2	Woolly Butt, S.C.	Woolly Butt, S.C.	{ Woolly Butt, S.C.
3	Turpentine, E.C.	Turpentine, S.C.	{ Grey Box, S.C.
4	Turpentine, S.C.	Turpentine, S.C.	{ Turpentine, S.C.
5	Blackbutt, S.C.	Brush Box, N.C.	{ Brush Box, N.C.
6	Grey Box, S.C.	Grey Box, S.C.	{ Blackbutt, S.C.
7	Grey Ironbark, N.C.	Spotted Gum, S.C.	{ Spotted Gum, S.C.
8	Stringy Bark, S.C.	Blackbutt, S.C.	Blue Gum, N.C.
9	Brush Box, N,C.	{ Grey Ironbark, N.C.	Grey Gum, N.C.
10	Colonial Teak, N.C.	{ Blue Gum, N.C.	{ Blackbutt, N.C.
11	White Mahogany, N.C.	White Mahogany,N.C.	{ Tallow Wood, N.C.
12	Blackbutt, N.C.	Grey Gum, N.C.	White Mahogany,N.C.
13	Grey Gum, N.C.	Blackbutt, N.C.	Turpentine, N.C.
14	Red Mahogany, N.C.	Red Mahogany, N.C.	Red Mahogany, N.C.
15	Tallow Wood, N.C.	Tallow Wood, N.C.	Stringy Bark, S,C.
16	Blue Gum, N.C	Colonial Teak, N.C,	Colonial Teak, N.C.

Table IV.—ORDER.

Name.	No.	C	B	A	C, B and A
NORTH COAST.—					
Blackbutt ...	1	12	13	10	35
Tallow Wood ...	2	15	15	10	40
Grey Gum ...	3	13	12	9	34
Grey Ironbark ...	4	7	9	1	17
Blue Gum ...	6	16	9	8	33
Brush Box ...	7	9	5	5	19
Turpentine ...	8	3	3	13	19
Red Mahogany ...	9	14	14	14	42
White Mahogany	10	11	11	12	34
Colonial Teak ...	11	10	16	16	42
SOUTH COAST.					
Grey Box ...	12	6	6	2	14
Woolly Butt ...	13	2	2	2	6
Spotted Gum ...	14	1	7	5	13
Turpentine ...	15	4	4	2	10
Blackbutt ...	16	5	8	5	18
Stringy Bark ...	18	8	1	15	24

Table V.—Order of Hardness in the three planes A, B and C.

1	Woolly Butt, S.C.	10	Blue Gum, N.C.
2	Turpentine, S.C.	11	Grey Gum, N.C.
3	Spotted Gum, S.C.	12	White Mahogany, S.C.
4	Grey Box, S.C.	13	Blackbutt, N.C.
5	Grey Ironbark, N.C.	14	Tallow Wood, N.C.
6	Blackbutt, S.C.	15	Red Mahogany, N.C.
7	Turpentine, N.C.	16	Colonial Teak, N.C.
8	Brush Box, N.C.		
9	Stringy Bark, S.C.		

A test was made on well seasoned New South Wales hardwood timbers comparing them with Western Australian jarrah. The specimens were obtained from samples kept in the Macleay Museum, cut from pieces which were tested in 1889, and were therefore very dry.

Table VI shows the results of testing these specimens in direction A as used in timber pavements. We see from this that spotted gum is the hardest of these four timbers

with blackbutt, tallow wood, and jarrah following in that order, but very close together.

TABLE VI.

Timber.	Weight abraded.	Mean.	Time of Test.	Weight reduced to two mins.	Weight per cub. foot.	Volume abraded 10	Volume reduced to standard hardness blackbutt direction C = 100	Remarks.
Spotted Gum	20		5					These figures are strictly comparable with each other and also with Table I, and show the relative resistance to abrasion when used in a street pavement.
	17	19	5	7 6	71·1	25·4	22·4	
	20		5					
Blackbutt	22		5					
	19	20·6	5	8·24	59·6	34·1	28 9	
	21		5					
Tallow Wood	25		5					
	25	26·3	5	10·52	71·4	36·1	30·6	
	29		5					
Jarrah	21		5					
	24	22·3	5	8·92	56 2	39·1	33·2	
	22		5					

Explanation of Plates.

Plate LIV shows specimens of the various timbers after testing in direction A, *i.e.* parallel to the direction of the fibre.

Plate LV, specimens of the various timbers after being tested in direction B, *i.e.* perpendicular to direction of the fibre and also perpendicular to annual rings.

Plate LVI, specimens of the various timbers after testing in direction C, *i.e.* perpendicular to direction of the fibre and tangential to the annual rings.

Plate 1.

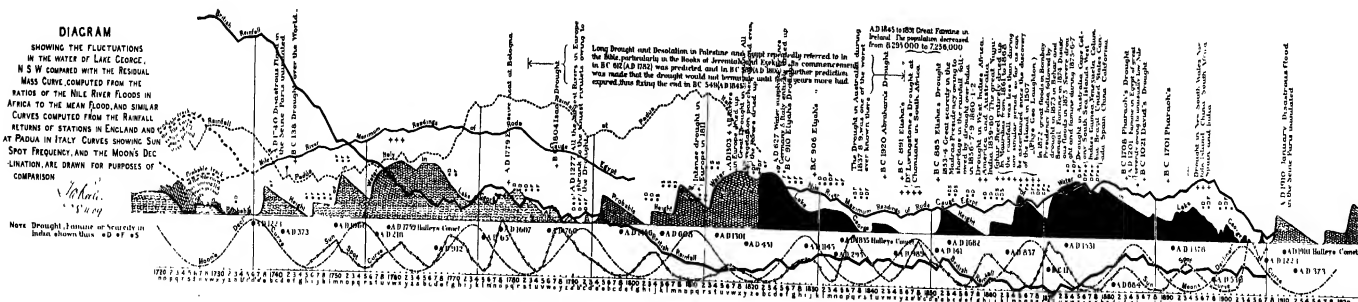
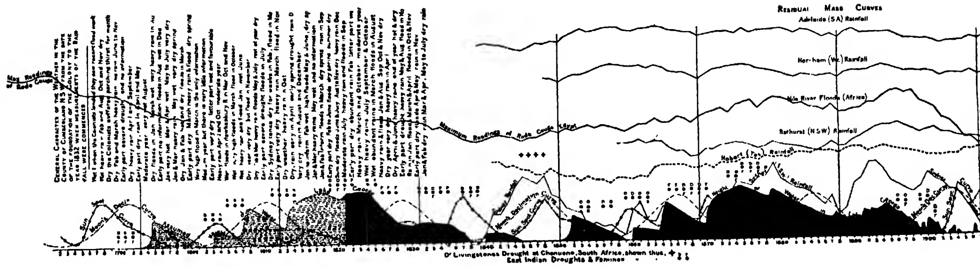


DIAGRAM
SHOWING THE FLUCTUATIONS IN THE WATER OF LAKE GEORGE, N S W COMPARED WITH THE RESIDUAL MASS CURVE, COMPUTED FROM THE RATIOS OF THE NILE RIVER FLOODS IN AFRICA TO THE MEAN FLOOD, AND SIMILAR CURVES COMPUTED FROM THE RAINFALL RETURNS OF STATIONS IN ENGLAND AND AT PADUA IN ITALY. CURVES SHOWING SUN SPOT FREQUENCY, AND THE MOON'S DECLINATION, ARE DRAWN FOR PURPOSES OF COMPARISON
Note Drought, Famine or Scarcity in India shown thus •D •F •S
British Rainfall
A D 1740 Disastrous Flood in the Seine Paris inundated
B C 138 Drought over the World.
A D 1779 Excessive heat at Bologna
B C 1804 Isaac's Drought
A D 1277 All the largest Rivers in Europe shrank to the smallest rivulets owing to the Drought
Long Drought and Desolation in Palestine and Egypt repeatedly referred to in the Bible, particularly in the Books of Jeremiah and Ezekiel. Its commencement in BC 612 (A D 1782) was predicted and in BC 589 (A D 1805) a further prediction was made that the drought would not terminate until forty years more had expired, thus fixing the end in BC 548 (A D 1845)
Intense drought in Europe in 1811
A D 1303 4 All Rivers in Europe dried up. Great Drought in all Europe. All vegetation parched and even the Rivers dried up
A D 627 Water supply failure Germany & Italy entirely dried up
B C 910 Elijah's Drought
B C 906 Elijah's
The Drought in Australia during 1837 8 9 was one of the worst ever known there
A D 1845 to 1851 Great Famine in Ireland. The population decreased from 8,295,000 to 7,256,000
B C 1920 Abraham's Drought
B C 891 Elisha's
Dr Livingstone's Drought at Chonuane in South Africa
B C 885 Elisha's Drought
1853-4 Great scarcity in the Madras Presidency owing to shortage in the rainfall followed by drought over India in 1856-7-9 1860-1-2
Drought in West Indies Africa, America and Australia
India 1859-60 The great Yuju-fghur Jheel entirely dried up
In Mauritius from 1861 to 1866 the rainfall was less than during any similar period so far as can be ascertained since the discovery of the Island in 1507 (Phye Geo Laughton)
In 1872 great floods in Bombay Presidency India followed by drought in 1873 in Behar and Bengal. Famine in 1874. Disastrous floods in 1875. Severe drought and famine during 1875-6-7
Drought in Australia Cape Colony South Sea Islands West Indies Guinea Venezuela Columbia Brazil United States Canada Spain China California
B C 1708 Pharaoh's Drought
A D 1201 Famine in Egypt of great severity owing to unusually low Nile
B C 1021 David's Drought
B C 1701 Pharaoh's
Drought in New South Wales Norfolk Island China South Africa Spain and India
A D 1910 January Disastrous flood in the Seine Paris inundated
Nile River Maximum Readings
Maximum Readings of Rode at Padua
Egypt
Lake George Height
Moon's Declination
Sun Spot Curve
A D 1759 Halley's Comet
A D 1835 Halley's Comet
A D 1910 Halley's Comet

Fig. 1.



DIAGRAM

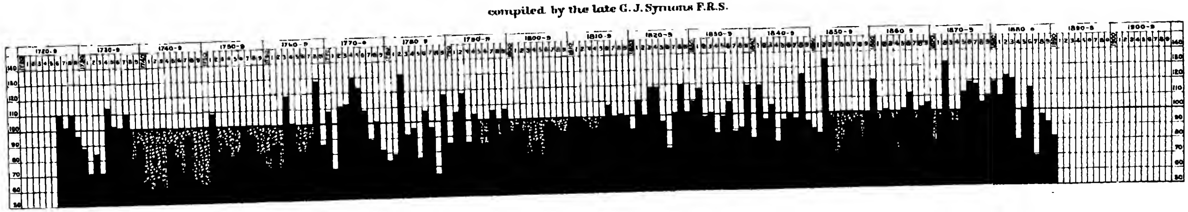
SHOWING THE FLUCTUATIONS IN THE WATER OF LAKE GEORGE, N.S.W. COMPARED WITH THE RESIDUAL MASS CURVE, COMPUTED FROM THE RATIOS OF THE NILE RIVER FLOODS IN AFRICA TO THE MEAN FLOOD, AND SIMILAR CURVES COMPUTED FROM THE RAINFALL RETURNS AT A FEW OF THE STATIONS IN AUSTRALIA WITH THE LONGEST RECORDS. CURVES SHOWING SUN SPOT FREQUENCY, AND THE MOON'S DECLINATION, ARE DRAWN FOR PURPOSES OF COMPARISON

Fig. 2.

DIAGRAM

SHOWING FLUCTUATION OF ANNUAL BRITISH RAINFALL

compiled by the late G. J. Symons F.R.S.



J. J. De la BILLARDIERE (1755 - 1834.)

BORY DE ST. VINCENT (1778-1846).

R. L. DESFONTAINES (1752-1833) in middle life.

R. L. DESFONTAINES (1752 - 1833) in very old age).

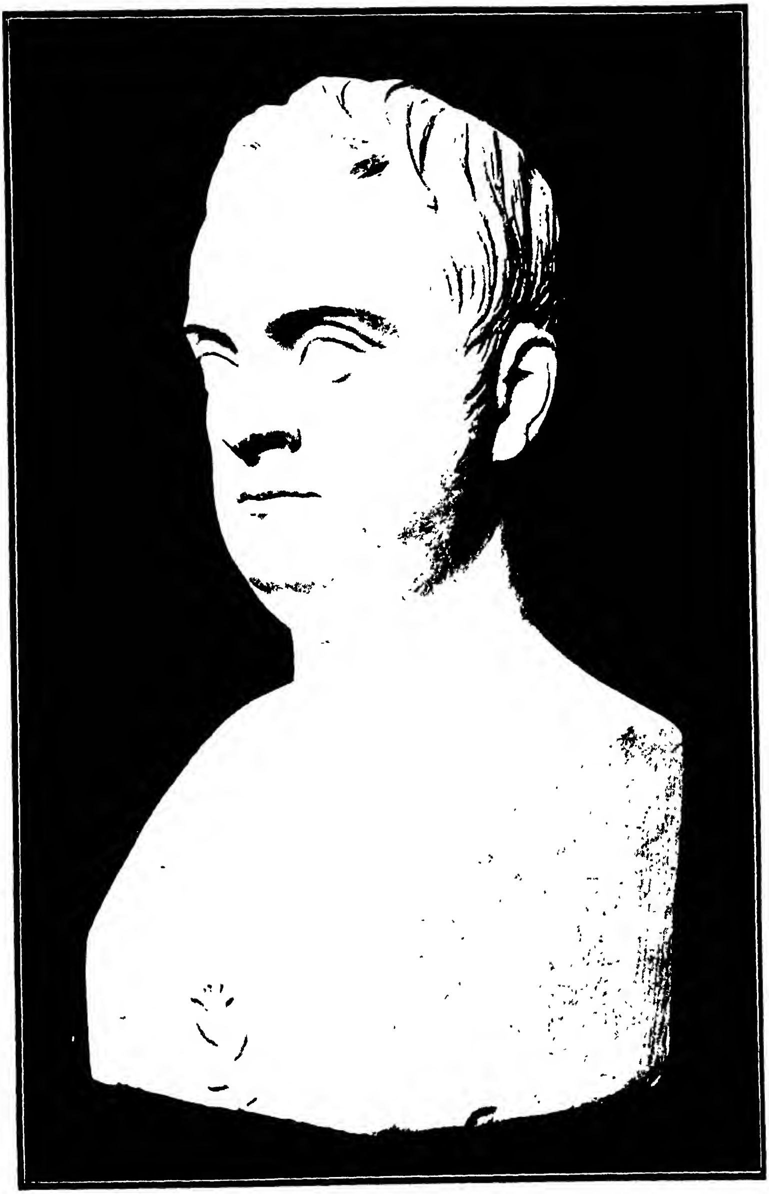
AIME BONPLAND (1773 - 1858).

ADRIEN DE JUSSIEU (1797–1853).

DUMONT D'URVILLE (1790 - 1842).

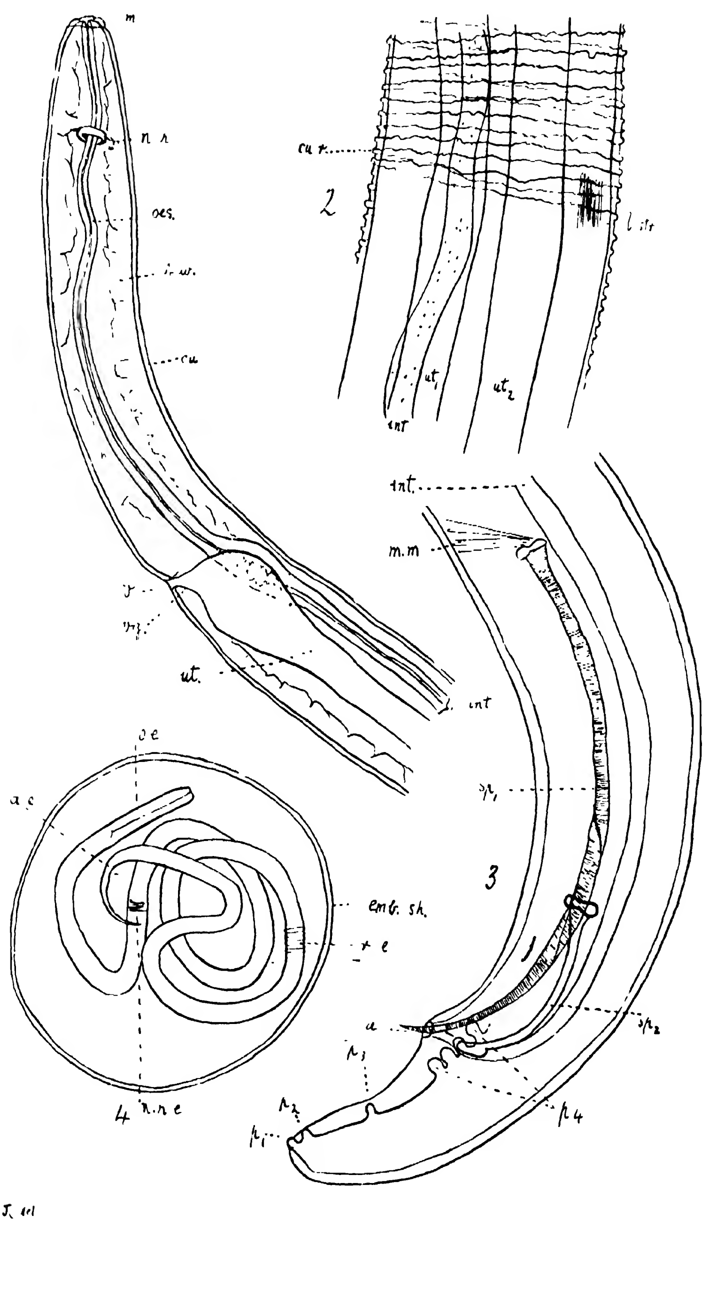
AD. BRONGNIART (1797 - 1853).

J. DECAISNE (1807 - 1882).



C. H. B. A. MOQUIN-TANDON (1804-1863).

J. E. PLANCHON (1823 - 1888).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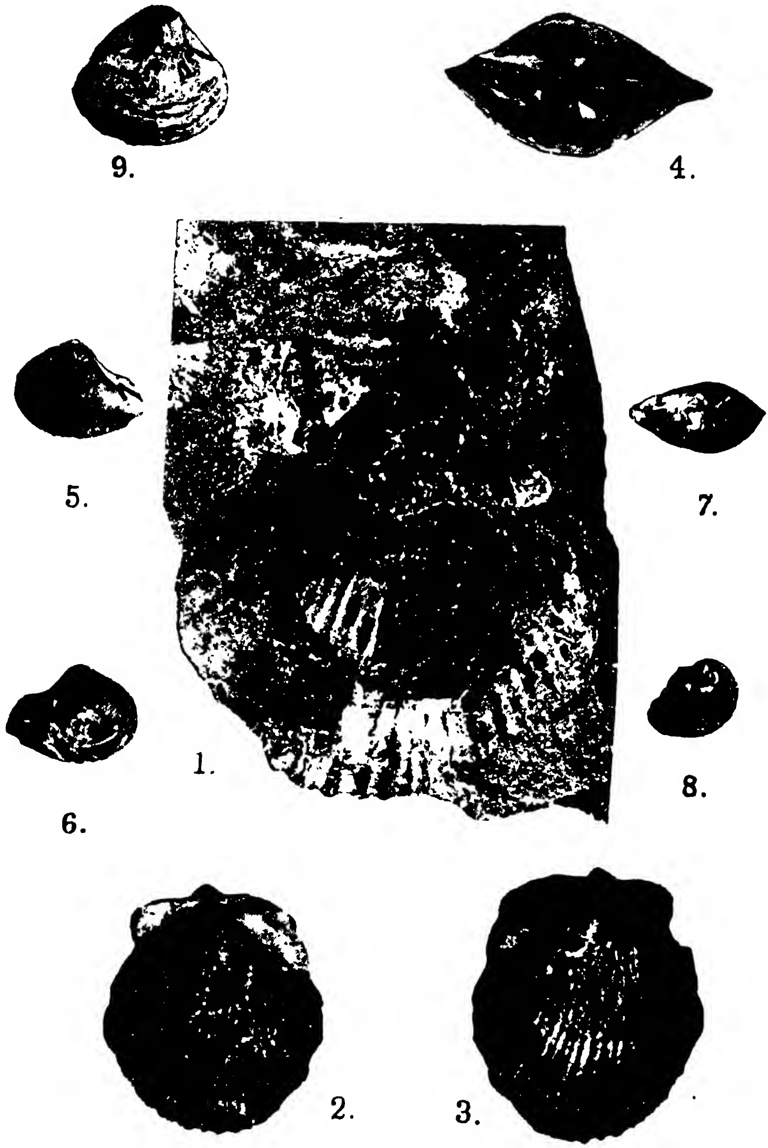
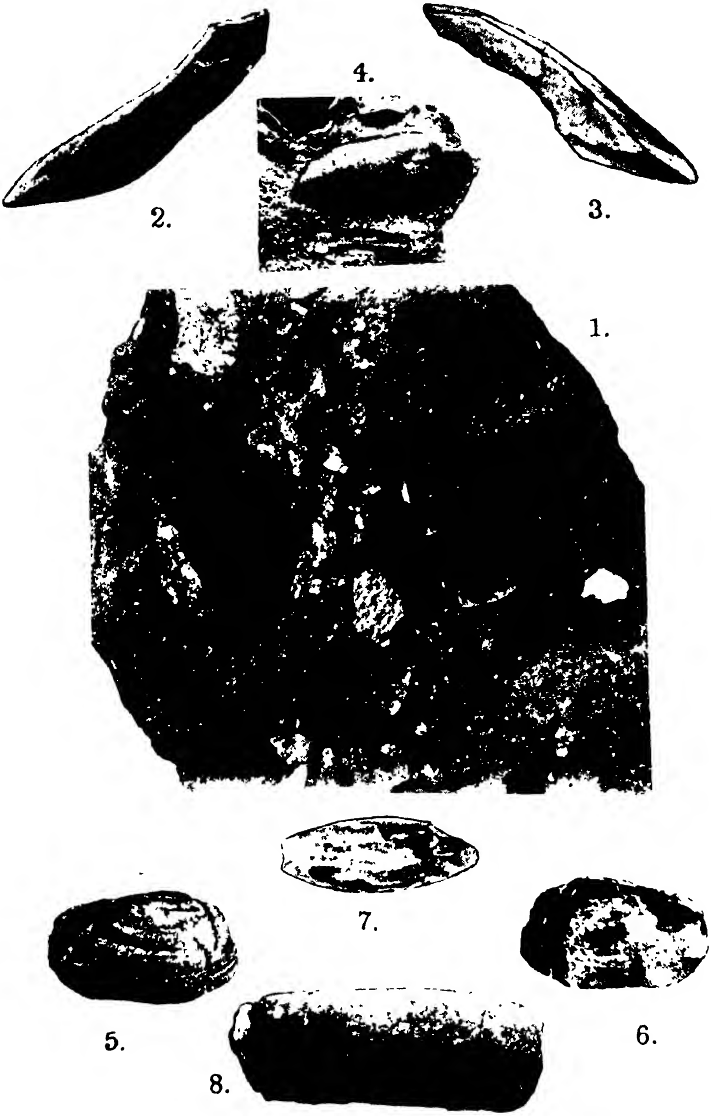
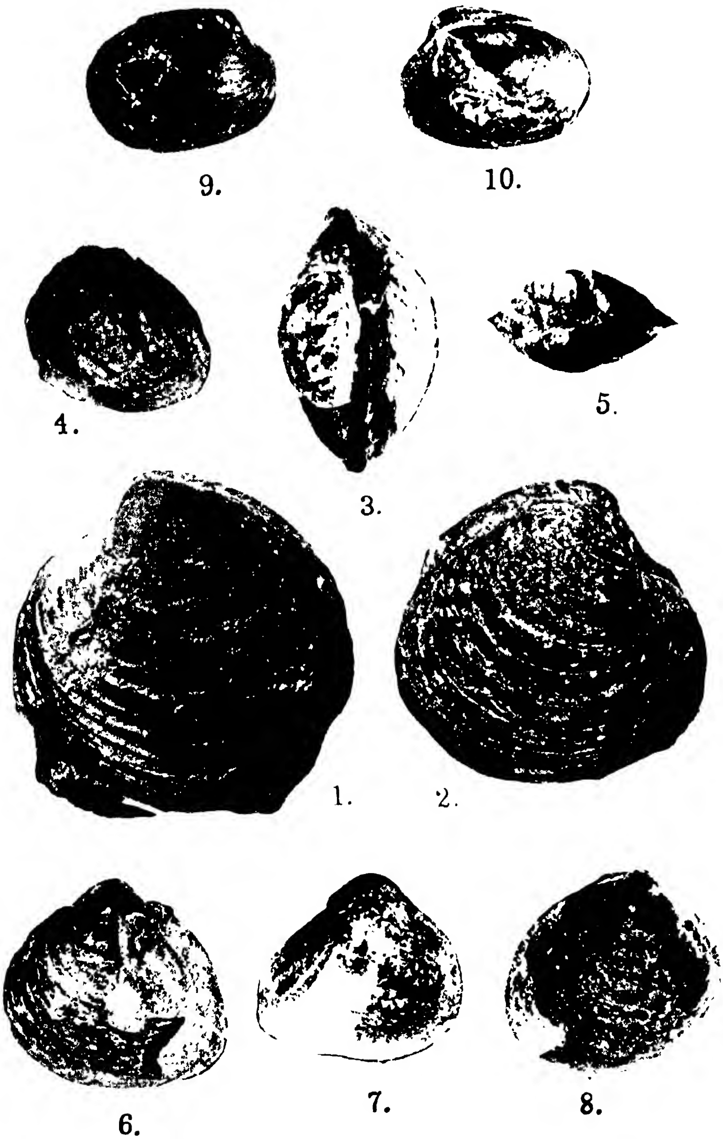


1, 2, Aviculopecten media, sp. nov., 3, opposite valve of the same specimen 4, the same viewed from above. 5, 6, 7, Nuculana ovata, sp. nov. 8, Capulus sp. 9, Dielasma hastata, G. de C. Sowerby var. globosa var. nov.

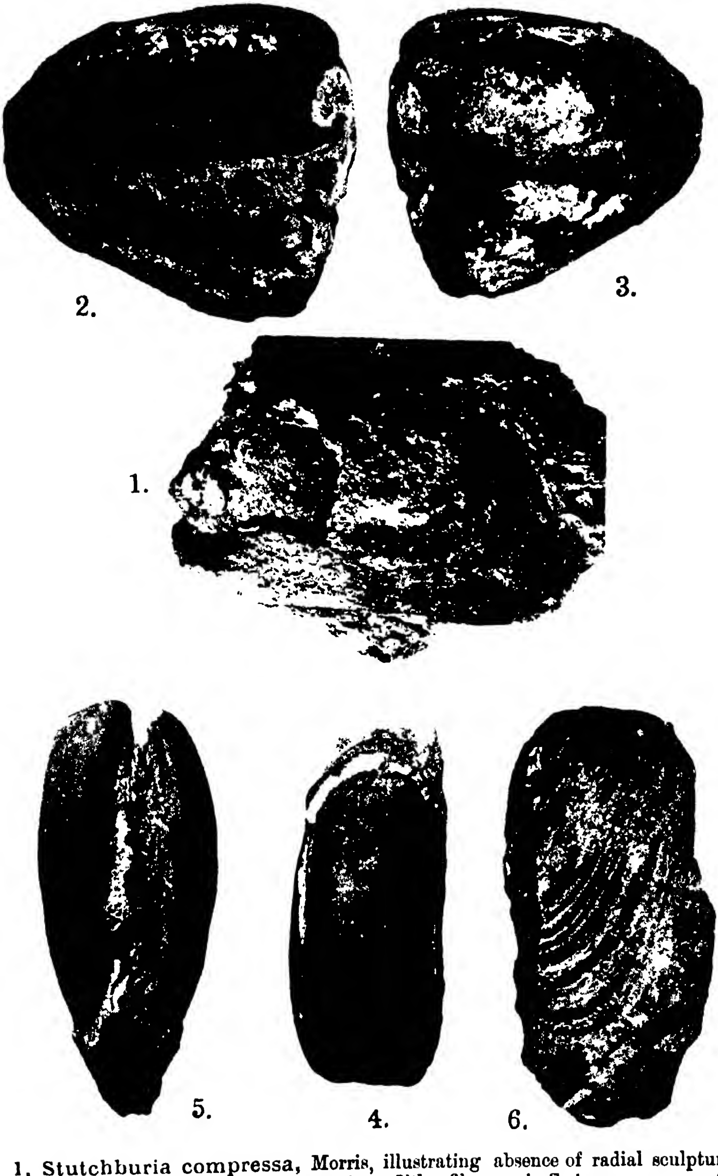
Cleobis robusta, sp. nov.



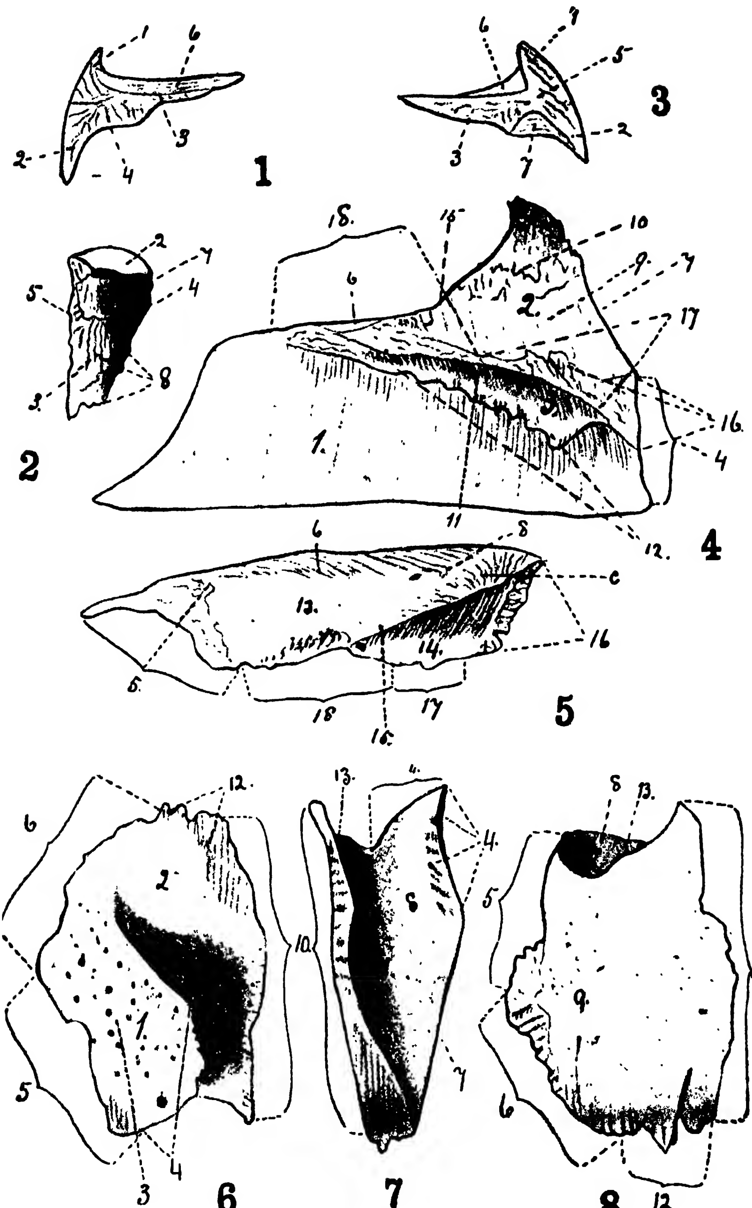
1, **Burriera Dunii**, gen. et sp. nov., 2, portion of the valve removed showing the thickening of the shell towards the lower anterior extremity.
3, the same specimen viewed from the interior. 4, **Solenomya translineata**, sp. nov., internal cast of right valve; 5, partially testiferous right valve showing sculpture: 6, left valve of the same specimen; 7, the same viewed from above. 8, **Solenopsis** sp.



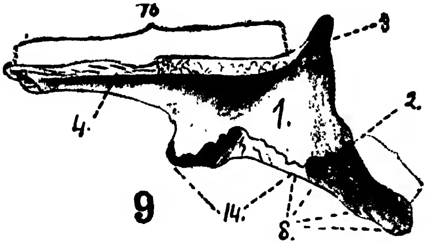
1, 2, Astartila sp. (Type A), 3, another specimen showing cardinal tooth, 4, Astartila sp. (Type B) left valve, 5, the same viewed from above showing impression of cardinal tooth, 6, 7, 8, Astartila sp. (Type C) 9, 10, Astartila sp. (Type D).



1, Stutchburia compressa, Morris, illustrating absence of radial sculpture 2, 3, Pleurophorus gregarius, Eth. fil. var. inflata, var. nov., 4, another internal cast; 5, the same viewed from above showing hinge region; 6, a testiferous example showing sculpture.



H. L. P. del.



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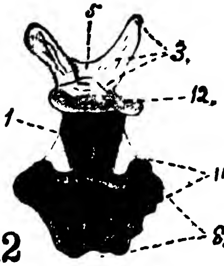

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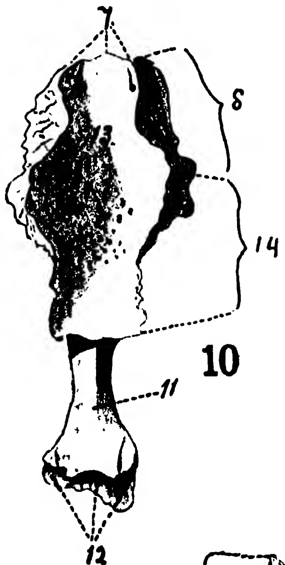

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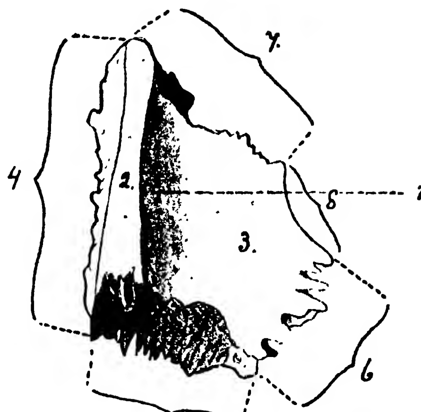

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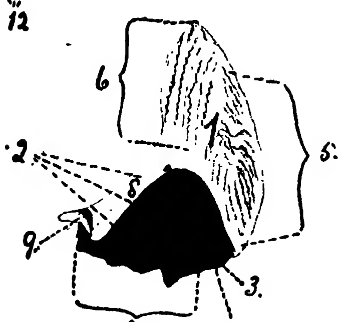

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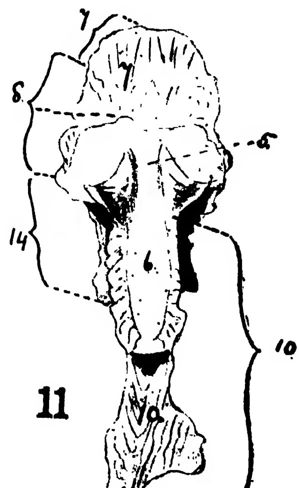

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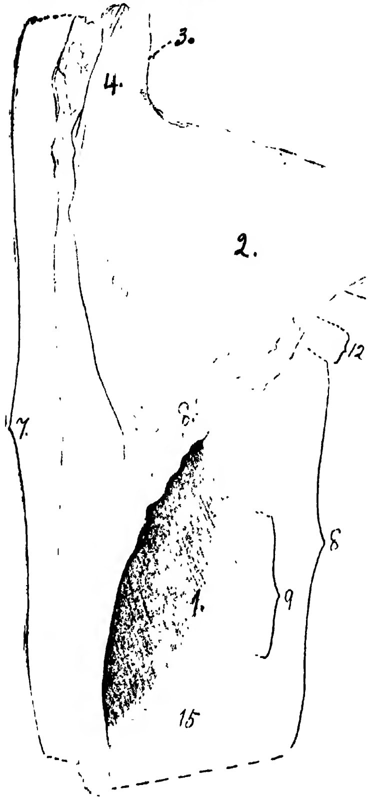
W.J.K. del.



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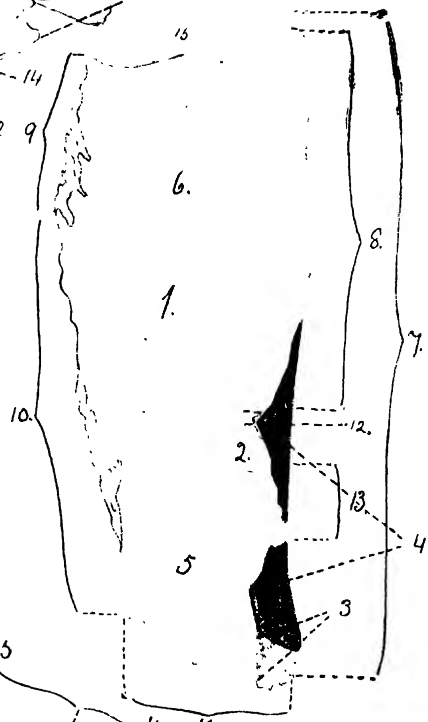

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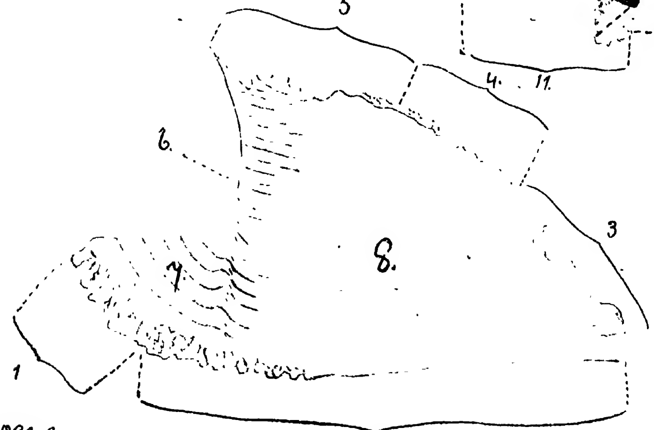

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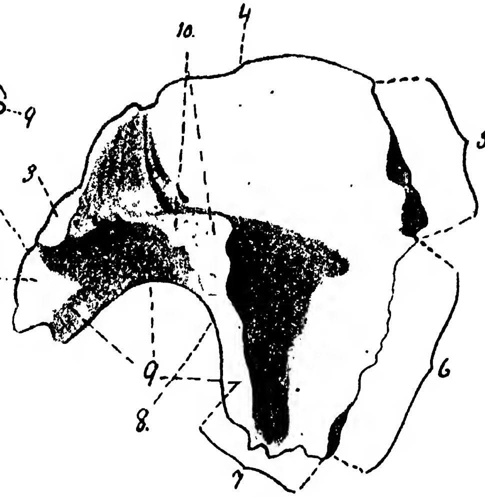
W.G.W. del.

19



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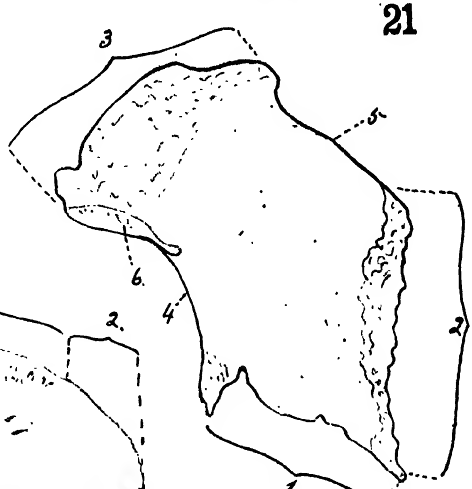

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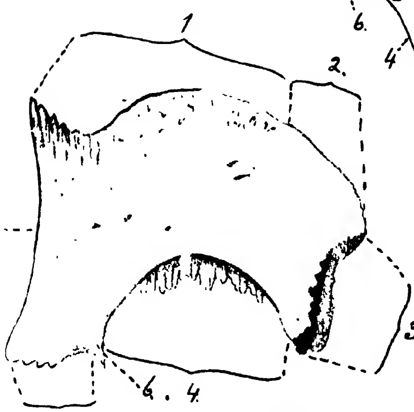

20

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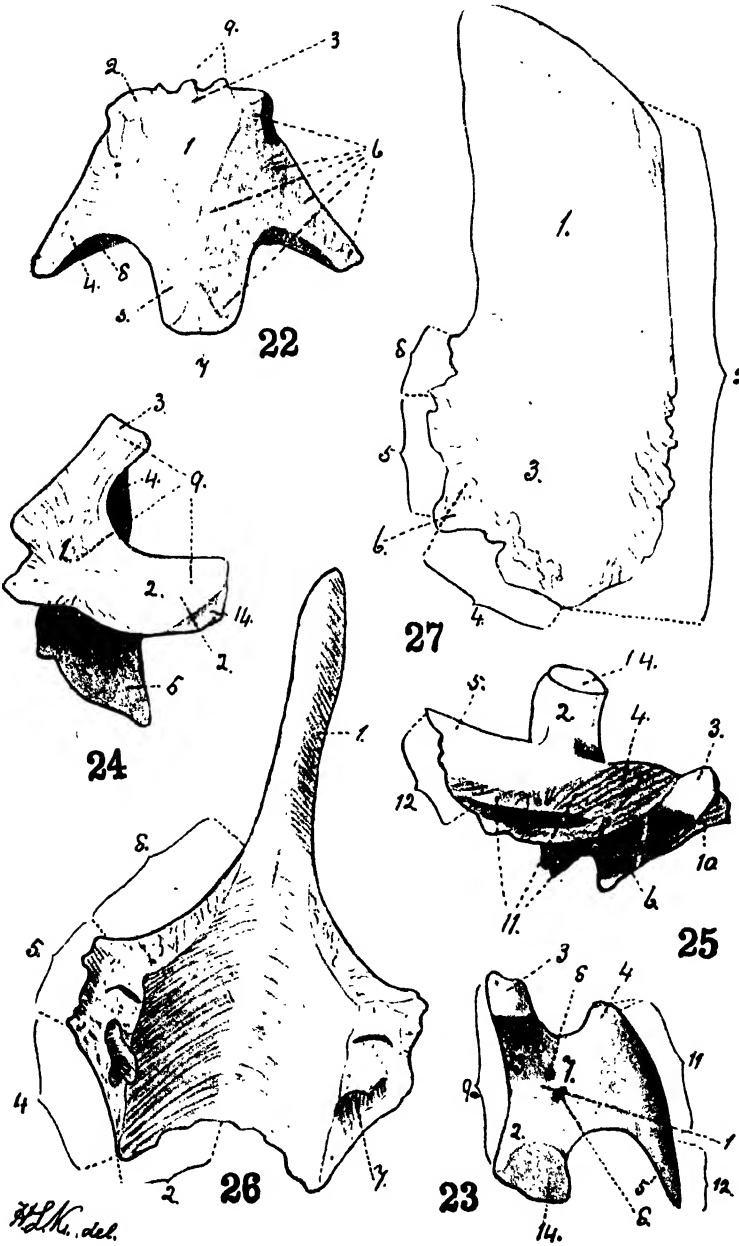
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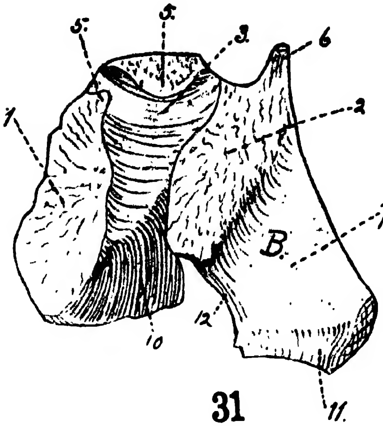
H.L.K. del.

29



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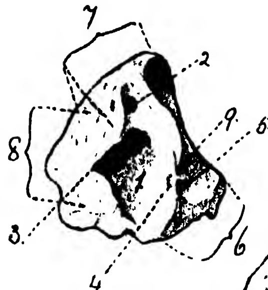

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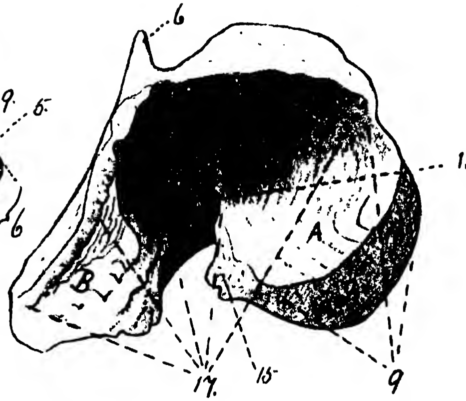

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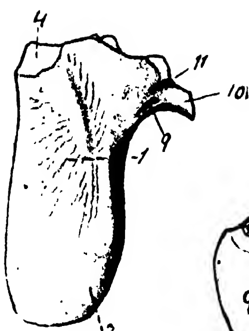

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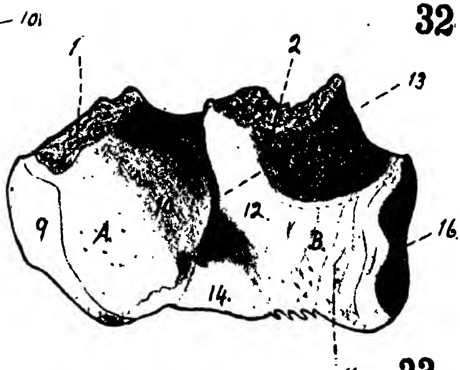

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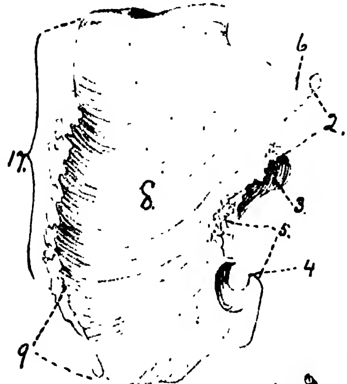
J.K. del.



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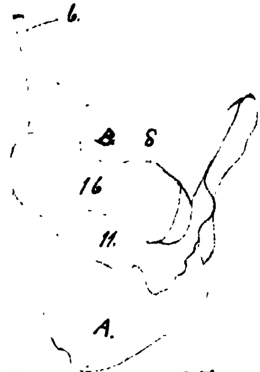

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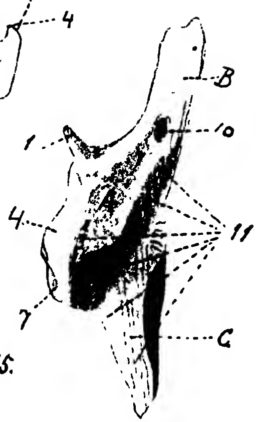

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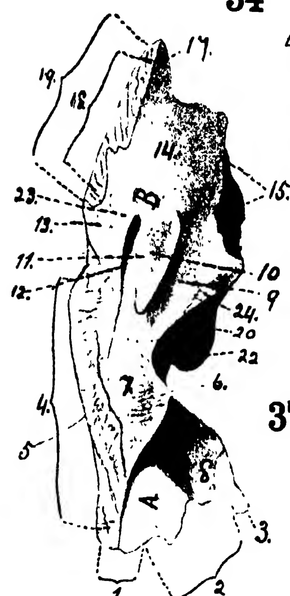

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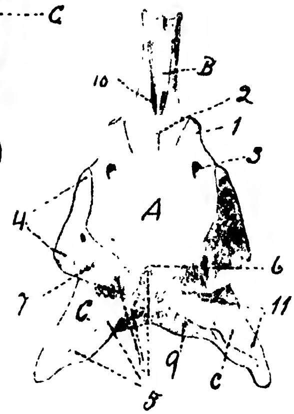

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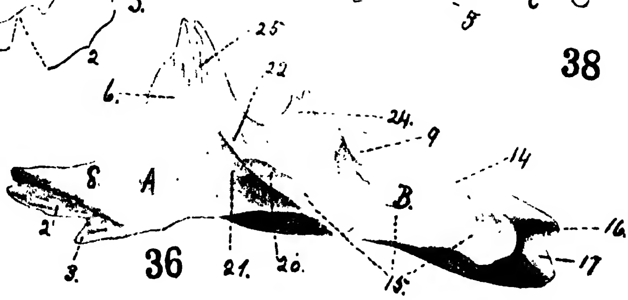

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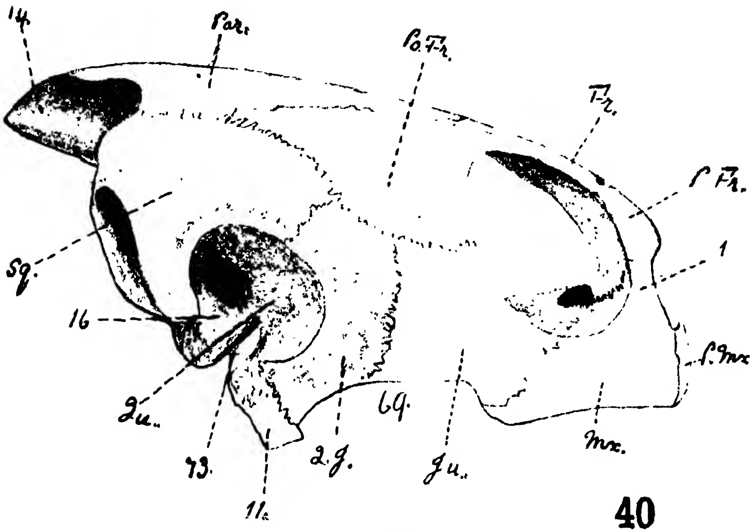
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Par.
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Q.J.
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Mx.
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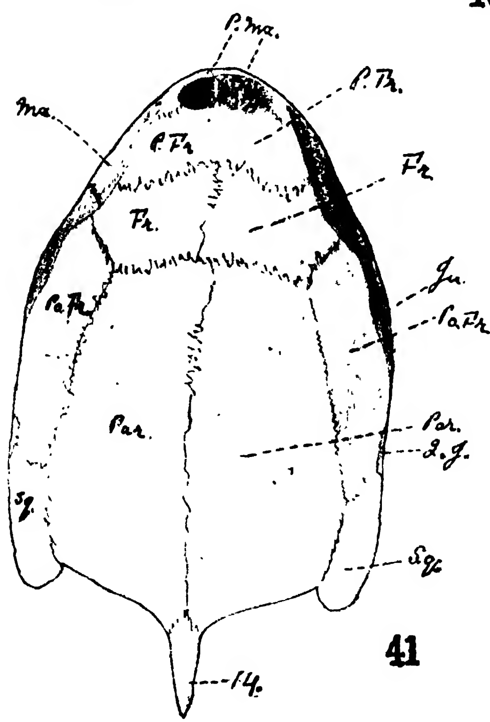
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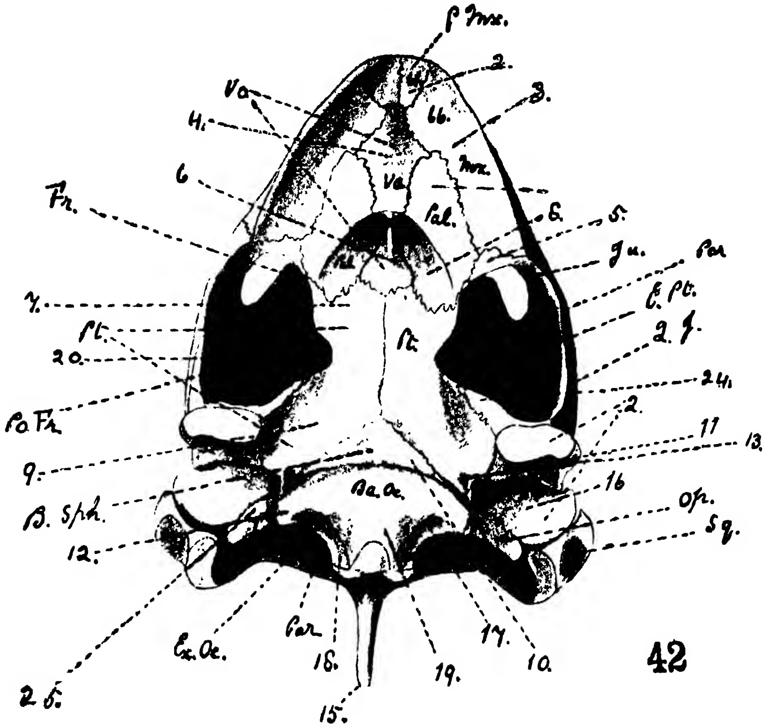
H.L.K. del.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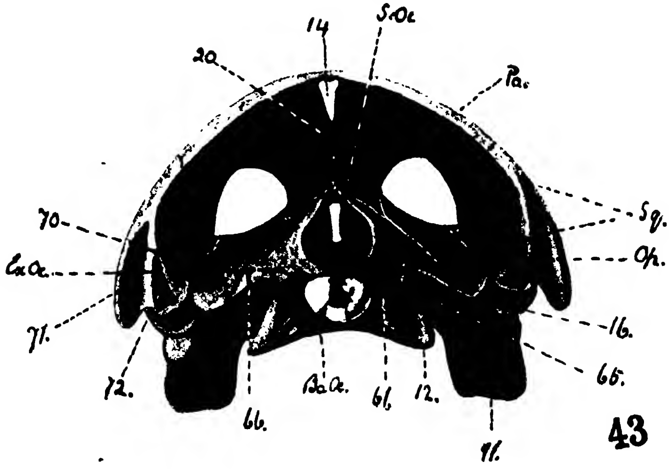
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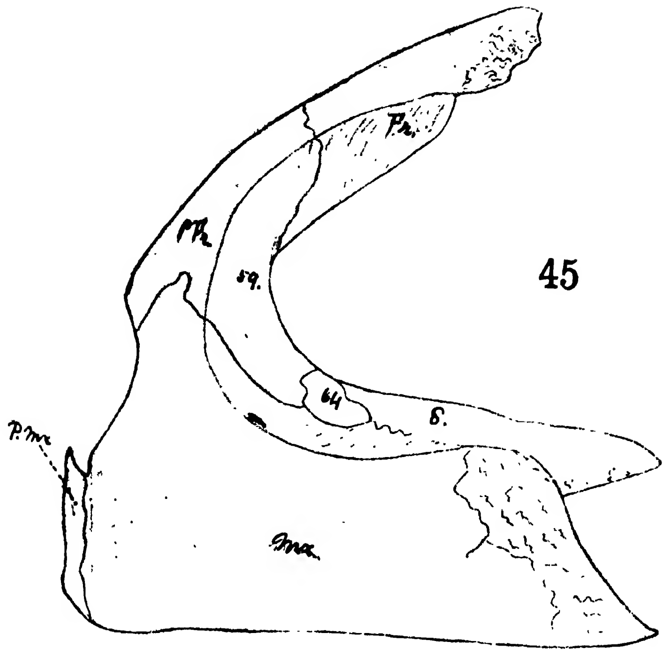
H.L. del.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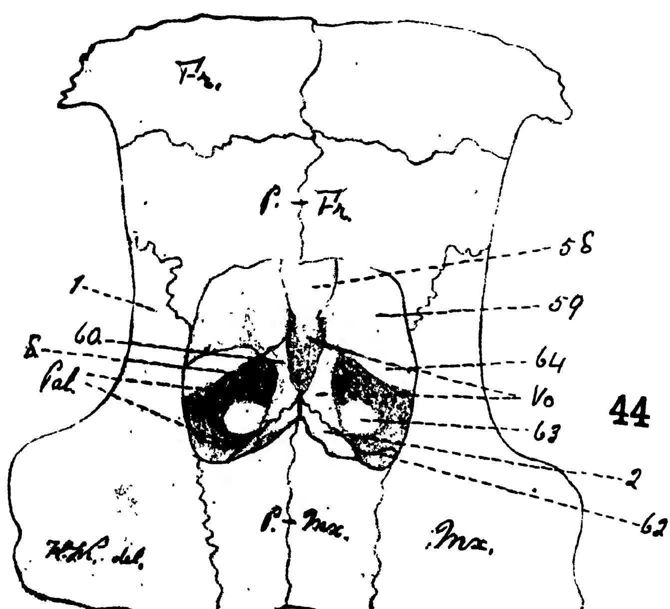
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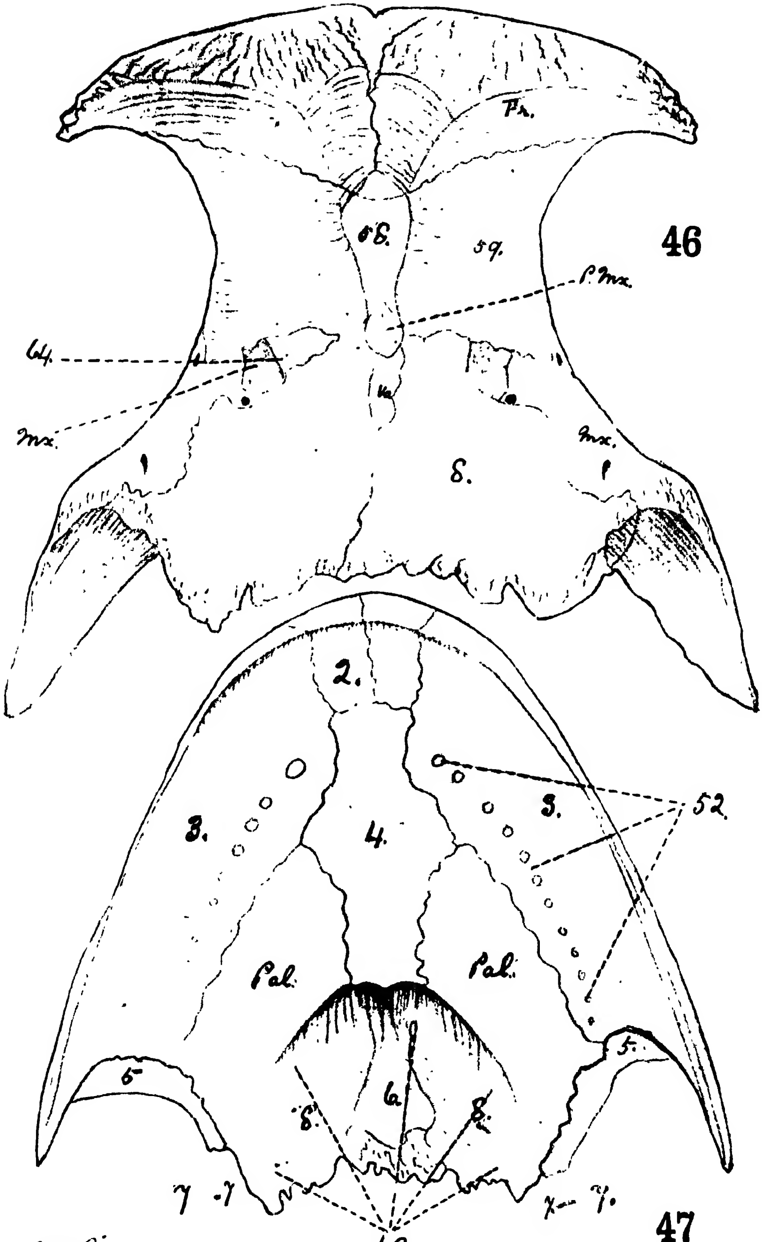
44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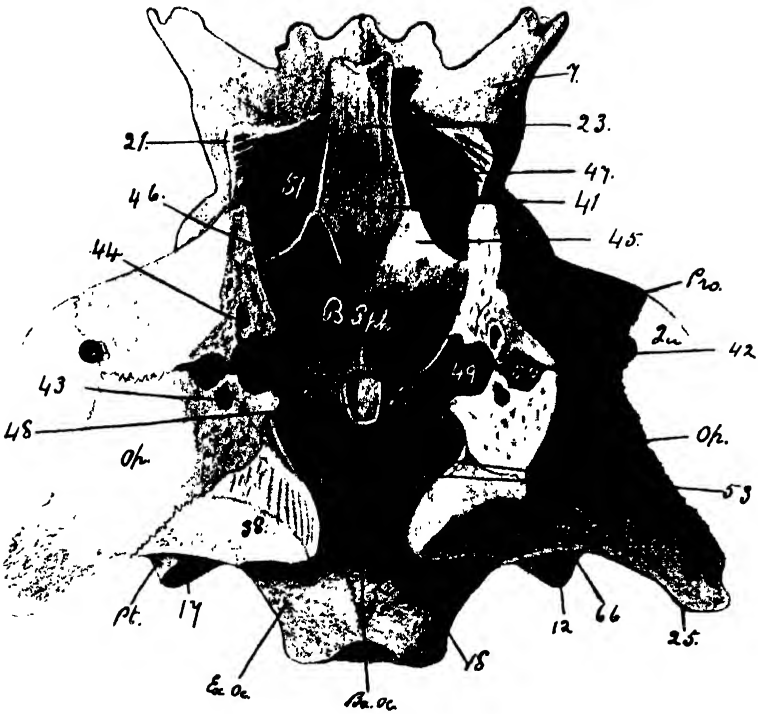
48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Ba. Oc.

W.L.K. del.

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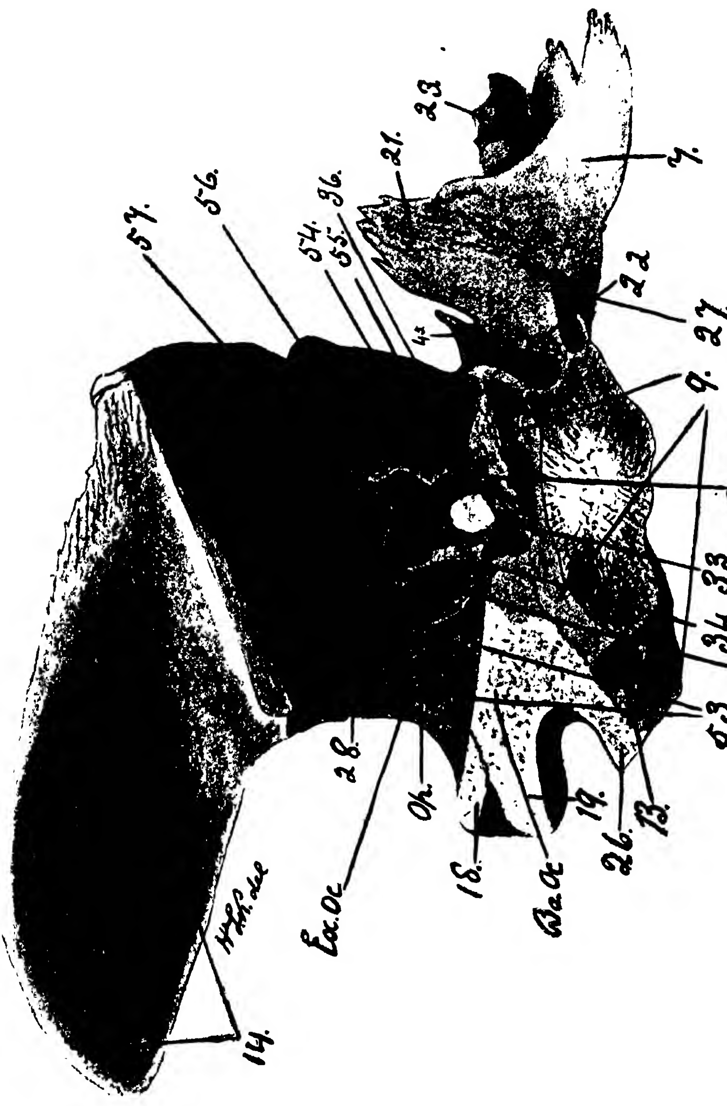

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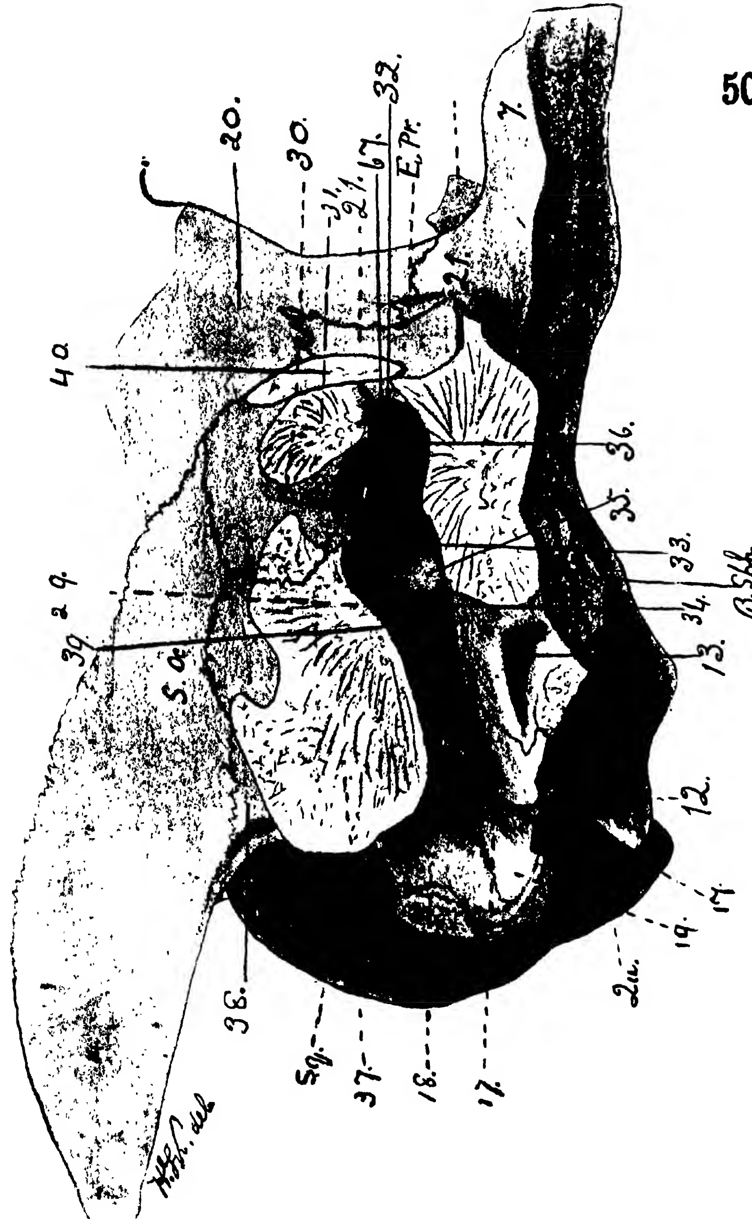
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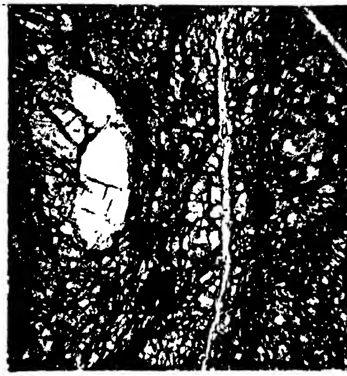

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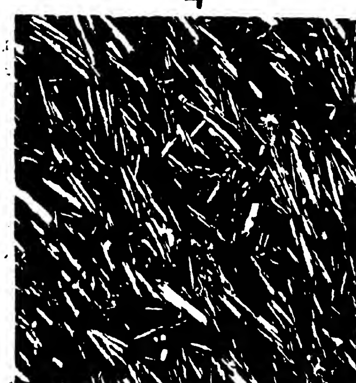


6

Fig. 1.

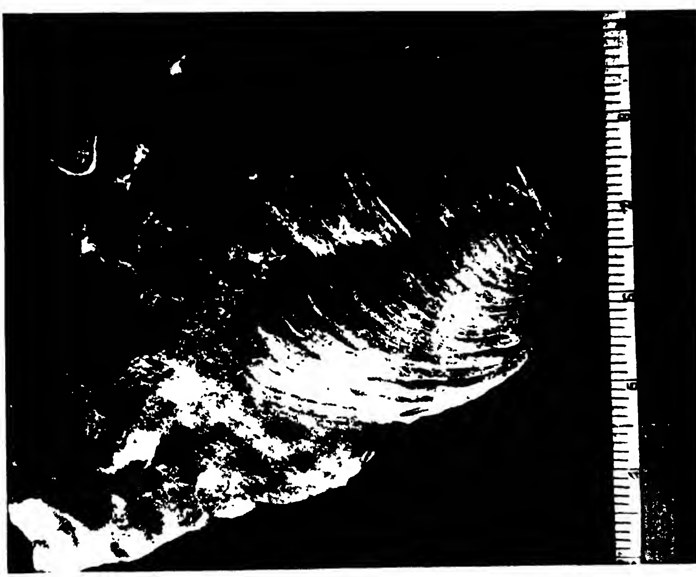


Fig.

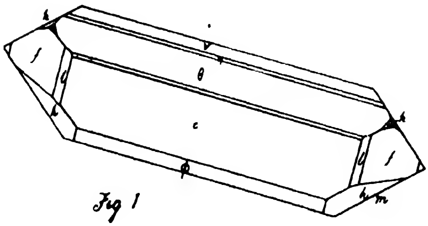
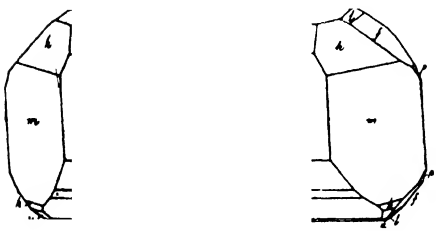


Fig 1



Fig

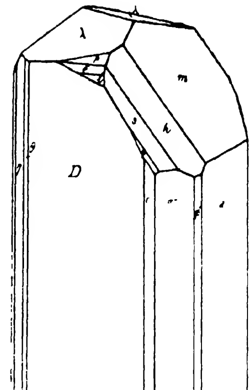


Fig 5.

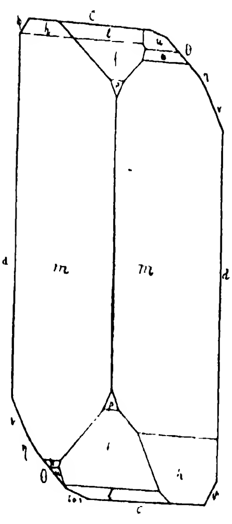


Fig 3

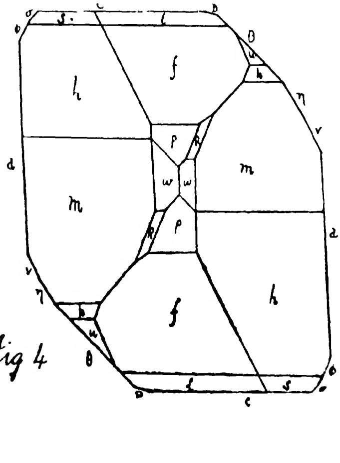


Fig 4

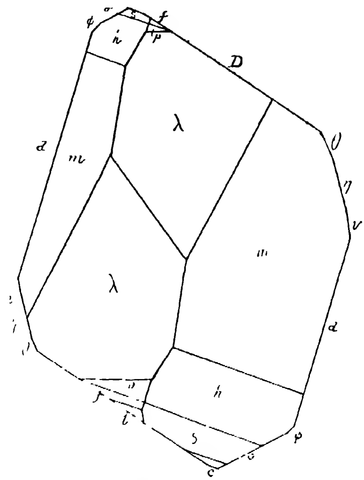


Fig 6

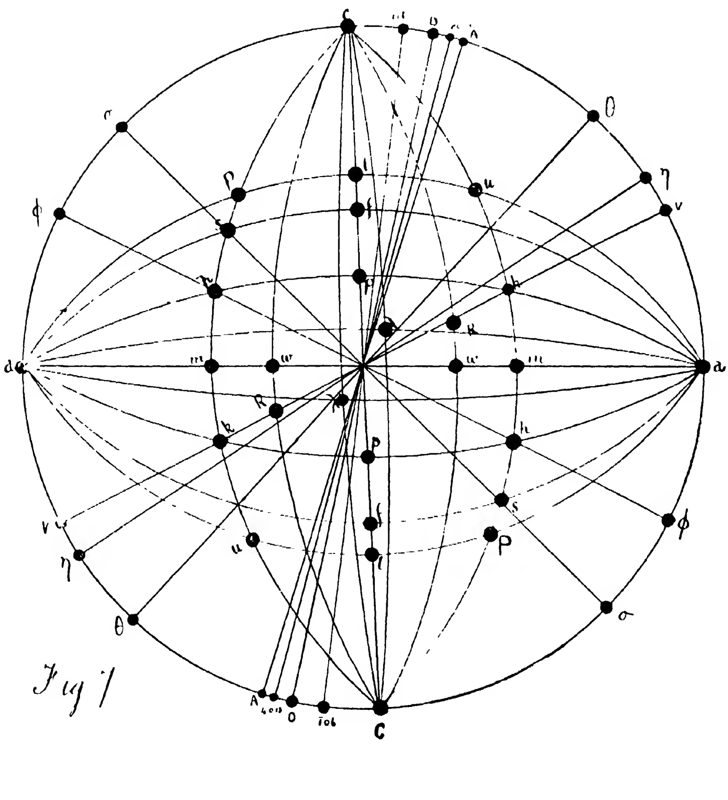
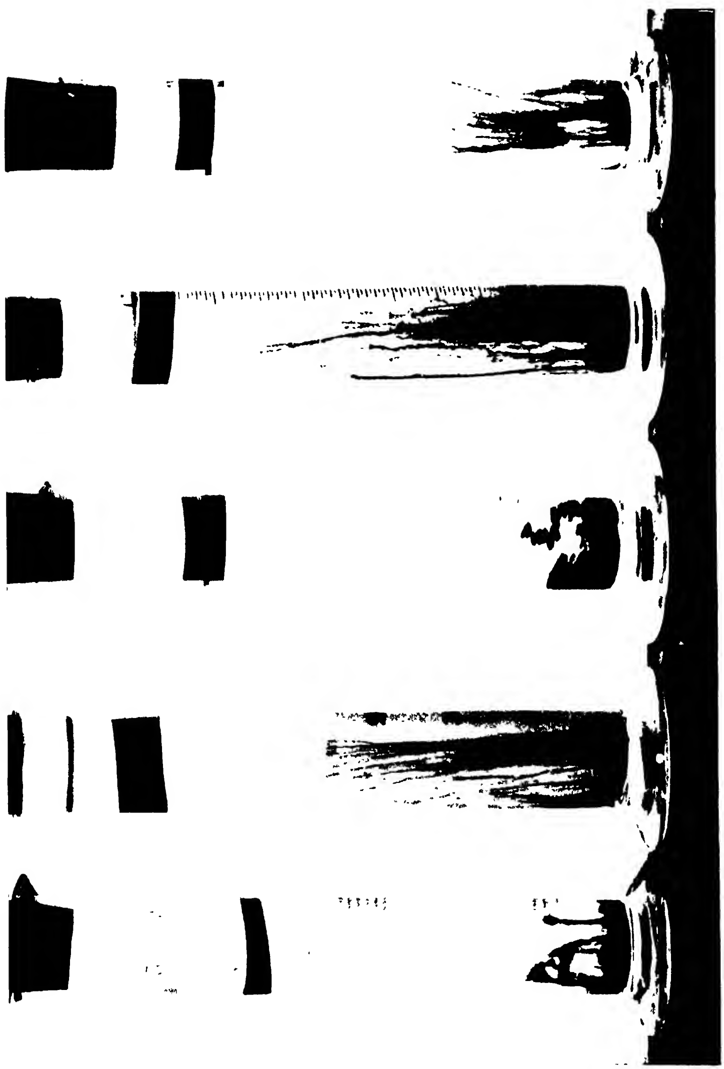


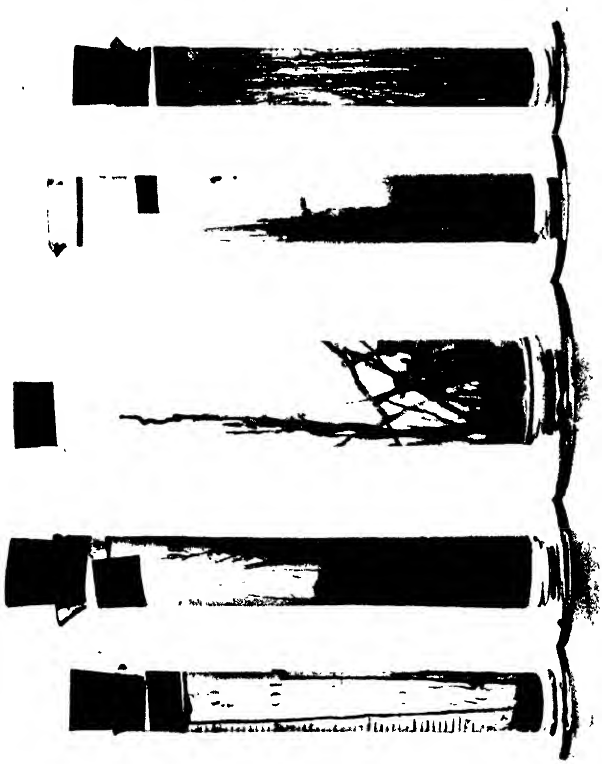
Fig 7



Nickel sulphate. Manganese chloride. Ferric chloride, Ferrous sulphate. Cobalt nitrate.

Photographs of Growths Produced by Various Salts.

Cadmium sulphate. Zinc sulphate. Calcium chloride.



Cupric chloride. Calcic chloride. Aluminic chloride. Zinc chloride. Cupric sulphate.

Melaleuca trichostachya. × 124

Fig. 2. × 93

Fig. 3. × 155

Melaleuca trichostachya.

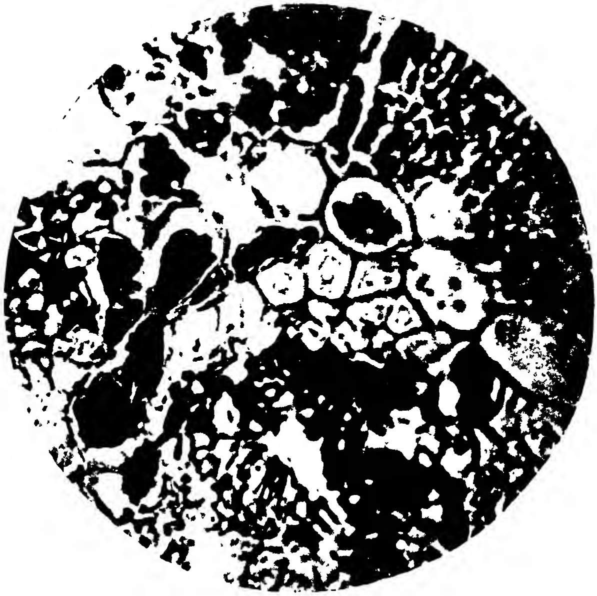


Fig. 4. × 630

Melaleuca trichostachya.

Fig. 5. × 93

Melaleuca bracteata.

Fig 6 × 155

Fig 7. × 155

Melaleuca bracteata.

Fig 8. × 630

Fig. 9. × 378

Melaleuca bracteata.

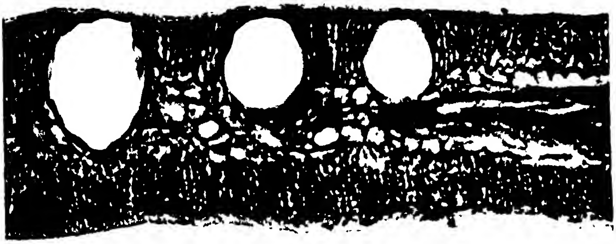


Fig. 10. × 155

Fig. 11. × 378

Melaleuca bracteata.

R.T.B., del. ad nat. H.J.A. Baron lit.

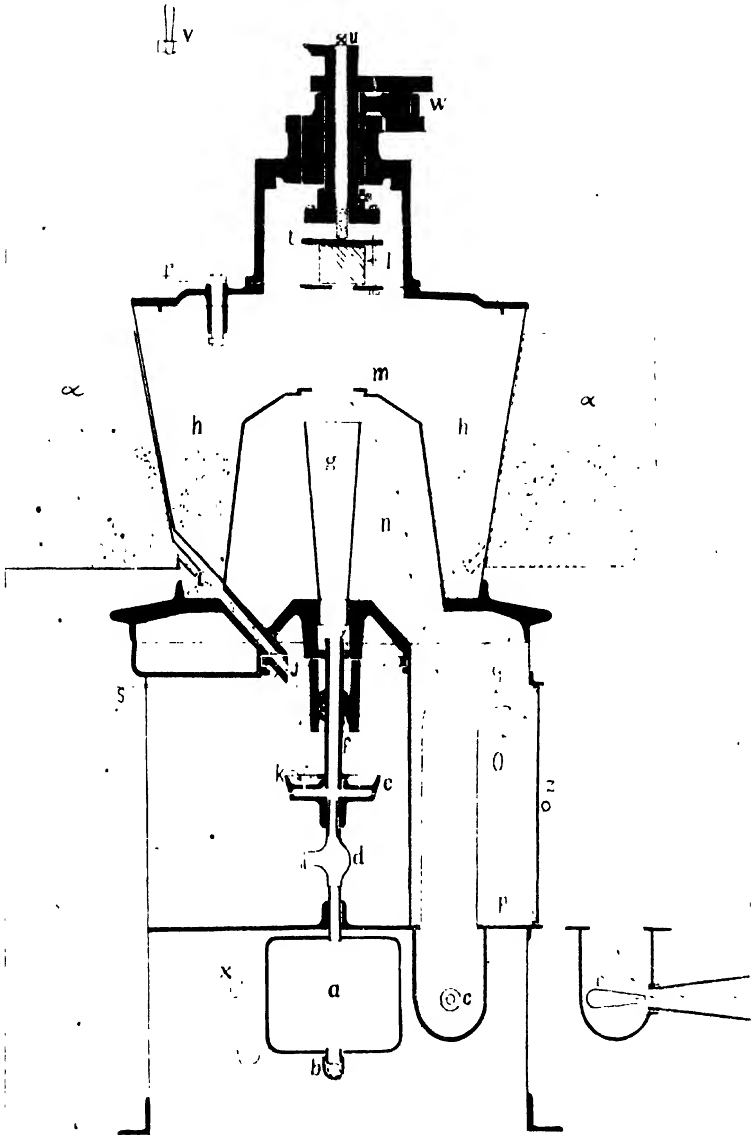
MELALEUCA TRICHOSTACHYA, F.v.M.

R. T. B., del ad nat. H J A Baron, lith

MELALEUCA BRACTEATA, F. v M.

Fig. 1

Fig. 2.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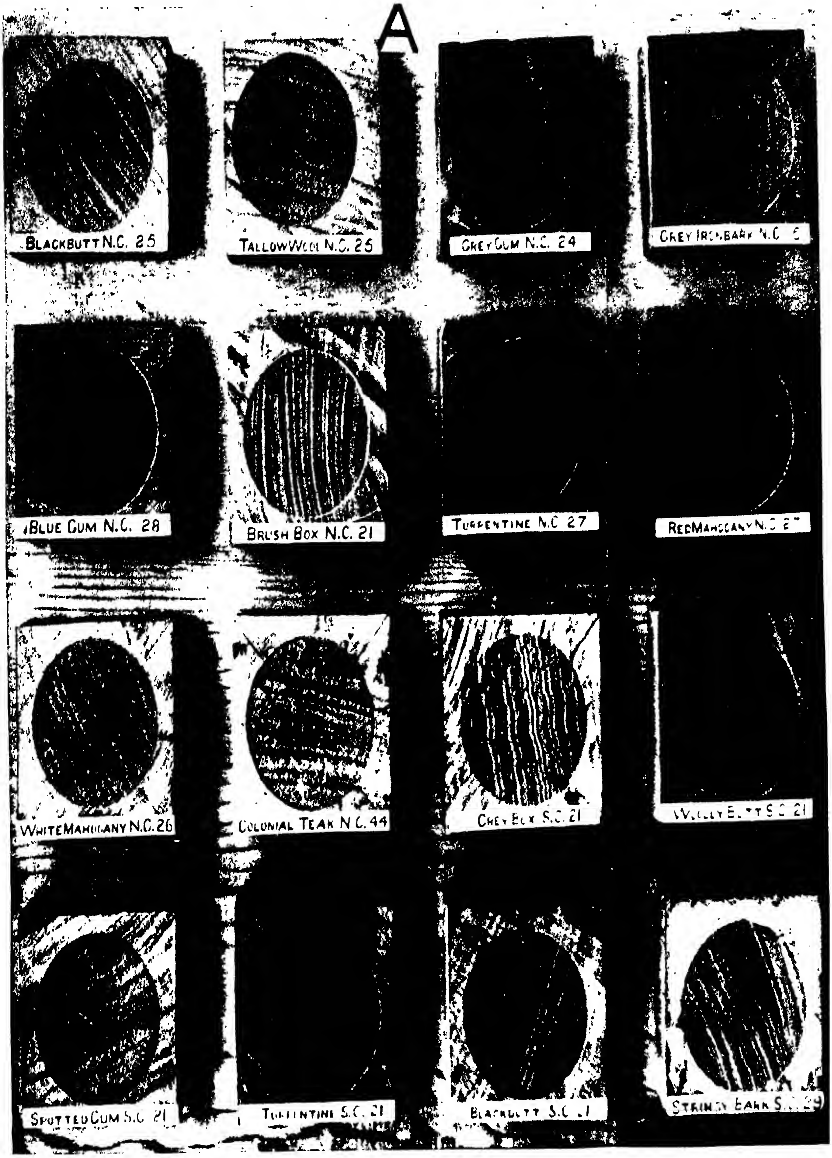
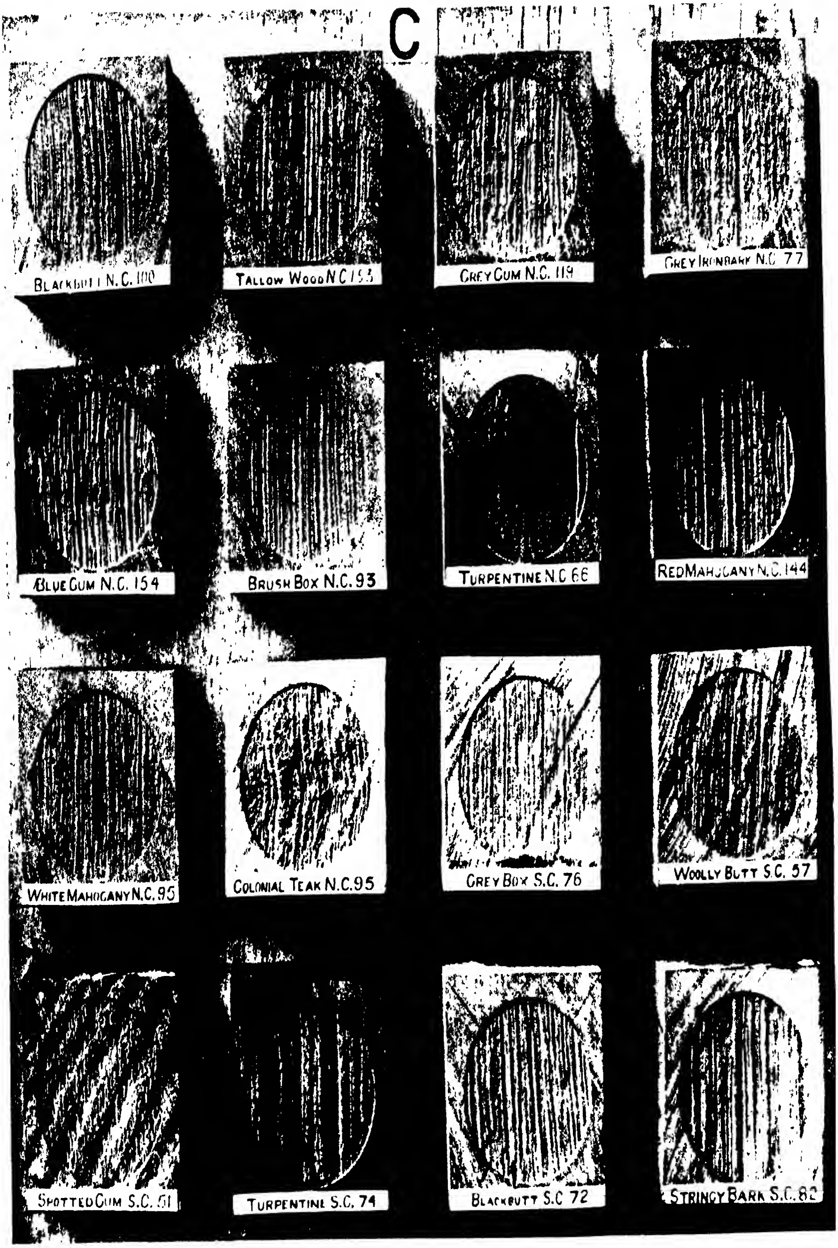

A
BLACKBUTT N.C. 25
TALLOW WOOD N.C. 25
GREY GUM N.C. 24
BLUE GUM N.C. 28
BRUSH BOX N.C. 21
TURPENTINE N.C 27
WHITE MAHOGANY N.C. 26
COLONIAL TEAK N C. 44
GREY BOX S.C. 21
SPOTTED GUM S.C 21
TURPENTINE S.C. 21


B
BLACKBUTT N.C. 76
TALLOWWOOD N.C. 103
GREY GUM N.C. 66
GREY IRONBARK N.C. 55
BLUE GUM N.C. 55
BRUSH BOX N.C. 42
TURPENTINE N.C. 37
RED MAHOGANY N.C. 86
WHITE MAHOGANY N.C. 62
COLONIAL TEAK N.C. 126
GREY BOX S.C. 43
WOOLLY BUTT S.C. 36
SPOTTED GUM S.C. 44
TURPENTINE S.C. 38
BLACKBUTT S.C. 53
STRINGY BARK S.C. 33


C
BLACKBUTT N.C. 100
TALLOW WOOD N.C 153
GREY GUM N.C. 119
GREY IRONBARK N.C 77
BLUE GUM N.C. 154
BRUSH BOX N.C. 93
TURPENTINE N.C 66
RED MAHOGANY N.C. 144
WHITE MAHOGANY N.C. 95
COLONIAL TEAK N.C.95
GREY BOX S.C. 76
WOOLLY BUTT S.C. 57
SPOTTED GUM S.C. 61
TURPENTINE S.C. 74
BLACKBUTT S.C 72
STRINGY BARK S.C. 82

ABSTRACT OF PROCEEDINGS

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

ABSTRACT OF PROCEEDINGS, MAY 4, 1910.

The Annual General Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, May 4th, 1910.

H. D. WALSH, B.A.I., M. Inst. C.E., President, in the Chair.

Twenty-nine members were present.

The minutes of the preceding meeting were read and confirmed.

The Annual Report of the Council was then read and adopted.

ANNUAL REPORT OF THE COUNCIL.

The Council submit to the members of the Royal Society of New South Wales their Report for the year ended 30th April, 1910.

The number of members on the roll 30th April, 1909, was 325; 22 new members have been elected during the past year. We have however lost by death five ordinary and one Honorary Member, also nine by resignation. There is thus left a total of 333 on the 30 April, 1910; this number however does not include the Honorary Members. The losses by death were :—

Honorary Member:

Professor SIMON NEWCOMB, elected 1901.

Ordinary Members:

COLYER, J. U. C., elected 1876.
DARLEY, Sir FREDERICK, elected 1877.
FOSTER, Honble. W. J., elected 1881.
KIRKCALDIE, DAVID, elected 1892.
WADE, J. S., elected 1906.

Books and periodicals have been purchased at a cost of £70 5s. 4d,, binding books amounted to £20 5s., making the sum expended on the Library £90 10s. 4d. A number of unbound books and periodicals have been, and will continue to be, covered in a cheap style of binding which will make them accessible to the members.

The number of Institutions on the Exchange List is 432, and the publications received in exchange for the Society's Journal and Proceedings during the past year were 296 volumes, 2,022 parts, 149 reports, 413 pamphlets, and 48 maps, total 2,928.

During the past year the Society held eight meetings, at which 28 papers were read, the average attendance of members was 29.

The Geological Section which has been in abeyance since 1891, was resuscitated and held four meetings, at which abstracts of current geological literature were supplied, exhibits shown, and subjects submitted for discussion next year.

A series of Popular Lectures, illustrated by lantern slides, was delivered during 1909 at the Society's House at 8 p.m. as follows:—

June 22—"*Antarctic Notes*," by Professor T. W. E. DAVID, B.A., F.R.S.
July 15—"*Some recent work in connexion with Radio-activity*," by J. P. V. MADSEN, B.E., D.Sc.
Aug. 19—"*Art forms in Nature*," by E. J. GODDARD, B.A., B.Sc., Linnean Macleay Fellow in Biology.
Sept. 16—"*Torres Straits*," by C. HEDLEY, F.L.S.
Oct. 21—"*On Volcanic Action in Australia*," by H. I. JENSEN, D.Sc.

During the year the papers have been published in four parts issued on 30th July, 22nd October, 31st December, 1909, and 4th May, 1910. It is believed that this prompt publication of papers will be appreciated by members and that it will result in increased prosperity to the Society.

On the motion of Mr. F. B. GUTHRIE, seconded by Dr. QUAIFE, the report was adopted.

The following Financial Statement for the year ended 31st March, 1910, was preeented by the Hon. Treasurer, received and adopted :—

GENERAL ACCOUNT.

RECEIPTS.		£ s. d.	£ s. d.
Subscriptions	One Guinea	51 9 0	
	„ „ Arrears	7 7 0	
	Two Guineas	399 0 0	
	„ „ Arrears	84 0 0	
	„ „ Advances ...	12 12 0	
			554 8 0
Parliamentary Grant on Subscriptions received—			
Vote for 1909-1910			400 0 0
Rent			346 1 0
Sundries			32 13 11
Exchange added to Country cheques			0 2 0
Clarke Memorial Fund—Loan			78 0 0
			1411 4 11
Balance on 1st April, 1909			24 17 8
			£1436 2 7

PAYMENTS.	£ s. d.
Advertisements	16 15 6
Assistant Secretary	270 0 0
Books and Periodicals	68 13 4
Bookbinding	20 5 0
Collector	1 9 6
Electric Light	27 10 2
Freight, Charges, Packing, &c....	21 5 9
Furniture and Effects	21 3 4
Gas	5 13 8
Caretaker	84 10 0
Carried forward	537 6 3

Payments—*continued.*	£ s. d.	£ s. d.
Brought forward		537 6 3
Insurance		18 6 2
Interest on Mortgage		124 0 0
Office Boy		24 6 0
Petty Cash Expenses		7 2 5
Postage Stamps		22 17 7
Printing		39 15 6
Printing and Publishing Journal		248 2 8
Printing Extra Copies of Papers		2 0 0
Rates		48 11 5
Repairs		15 5 10
Stationery		4 19 0
Sundries		38 3 1
		1130 15 11
Clarke Memorial Fund—Repaid on account Loan to Building and Investment Fund...	209 9 10	
Ditto, ditto, Interest	15 7 10	
		224 17 8
Ditto, ditto, Repaid Loan General Account ...	78 0 0	
Ditto, ditto, Interest	0 7 9	
		78 7 9
Bank Charges		0 12 6
Balance on 31st March, 1910		1 8 9
		£1436 2 7

BUILDING AND INVESTMENT FUND.

Dr.	£ s. d.
Loan on Mortgage at 4%	3100 0 0
Clarke Memorial Fund—Loan	18 15 11
	£3118 15 11

Cr.	£ s. d.
Deposit in Government Savings Bank, March 31st, 1910...	1 8 2
Balance of Account, March 31st, 1910...	3117 7 9
	£3118 15 11

CLARKE MEMORIAL FUND.

Dr.	£ s. d.
Amount of Fund, 31st March, 1909	477 9 2
Interest to 31st March, 1910	24 2 9
General Account Repaid on a/c Loan	78 0 0
Repaid on a/c to Building and Investment Fund	209 9 10
General Account, Balance...	2 3 6
	£791 5 3

Cr.	£	s.	d.
Deposit in Savings Bank of New South Wales, March 31, 1910	274	17	3
Deposit in Government Savings Bank, March 31, 1910 ...	10	2	3
Cash in hand since deposited in Government Savings Bank	200	0	0
Loan to General Account	78	0	0
Repaid on a/c Loan to Building and Investment Fund ...	209	9	10
Loan to Building and Investment Fund	18	15	11
	£791	5	3

AUDITED AND FOUND CORRECT, AS CONTAINED IN THE BOOKS OF ACCOUNTS.

W. PERCIVAL MINELL, F.C.P.A., *Auditor.*

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*

W. H. WEBB. *Assistant Secretary.*

SYDNEY, 2ND MAY, 1910.

The certificates of five candidates were read for the first time.

There being no other nominations, the following gentlemen were declared duly elected Officers and Members of Council for the current year, viz.:—

President:

Prof. T. W. E. DAVID, B.A., F.R.S.

Vice-Presidents:

HENRY DEANE, M.A., M. Inst. C.E.
WALTER SPENCER, M.D.
W. M. HAMLET, F.I.C., F.C.S.
H. D. WALSH, B.A.I., M. Inst. C.E.

Hon. Treasurer:

D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:

J. H. MAIDEN, F.L.S.
F. B. GUTHRIE, F.I.C., F.C.S.

Members of Council:

R. H. CAMBAGE, F.L.S.
A. DUCKWORTH, F.R.E.S.
R. GREIG-SMITH, D.Sc.
CHARLES HEDLEY, F.L.S.
T. H. HOUGHTON, M. Inst. C.E.
Prof. POLLOCK, B.E., D.Sc.
F. H. QUAIFE, M.A., M.D.
HENRY G. SMITH, F.C.S.
Prof. WARREN, M. Inst. C.E., Wh.Sc.
W. G. WOOLNOUGH, D.Sc., F.G.S.

The Chairman made the following announcements:—

1. SECTIONAL COMMITTEES—SESSION 1910.

Section C.—Geology, Palæontology.

Chairman—J. E. CARNE, F.G.S.

Hon. Secretary—C. A. SUSSMILCH, F.G.S. (Technical College)

Meetings of the Section will be held on

	April	May	June	July	Aug.	Sept.	Oct.	Nov.
	13	11	8	13	10	14	12	9

unless otherwise notified.

2. That the Society's Journal, Vol. XLIII, for 1909, was in the binder's hands and would be ready for delivery to members in a week or two.

3. Ninety-three volumes, 843 parts, 76 reports, 202 pamphlets, and 7 maps, total 1,221 received as donations since the previous meeting, were laid upon the table and acknowledged.

4. The following series of Popular Science Lectures, illustrated by lantern slides, experiments, or diagrams would be delivered during the present Session :—

June 16—"*The Velocity of Chemical Changes,*" by Professor FAWSITT, D. Sc., Ph. D., illustrated by experiments.

July 21—"*Early Blue Mountain Exploration, Barrallier's furthest West,*" by R. H. CAMBAGE, F.L.S.

August 18—"*The Mountains of New South Wales, their Nature and Origin,*" by C. A. SÜSSMILCH, F.G.S,

September 15—"*Modern Methods of Recording Earthquakes,*" by Rev. E. F. PIGOT, B.A., M.B.

October 20—"*The Social View of Capital,*" by R. F. IRVINE, M.A.

The following letter was read, from Dr. WALTER E. ROTH, B.A., Pomeroon River, British Guiana, acknowledging the award of the Clarke Memorial Medal :—

Pomeroon River, British Guiana, South America,
24th January, 1910.

Dear Sir,—I have just received the Clarke Memorial Medal and your accompanying letter of 5th November last. Please convey to the Council of the Royal Society of New South Wales my sincerest thanks and appreciation of the honour which they have thereby conferred on me. Although I myself do not consider my scientific researches into the ethnography of the North Queensland Aborigines worthy of so signal a reward, it at the same time gives me the necessary stimulus and encouragement, to continue my work on similar lines amongst the Guiana Indians—and to aim and strive at better results. Situated as I have been during the past three years, far from all the sweets and delights of civilisation, an even greater pleasure in the receipt of the medal, has been the knowledge, that though so many thousand miles away, I have not been forgotten. I am, dear sir, very faithfully yours, WALTER E. ROTH.

F. B. GUTHRIE, Esq., Hon. Sec., Royal Society of N.S. Wales.

Mr. H. D. WALSH, B.A.I., M. Inst. C.E., then read his Presidential Address.

A vote of thanks was, on the motion of Mr. HAMLET, seconded by Mr. LEVERRIER and supported by Dr. QUAIFE, passed to the retiring President, and Prof. T. W. E. DAVID, F.R.S., etc., was installed as President for the ensuing year.

Prof. DAVID thanked the members for the honour conferred upon him.

Prof. DAVID proposed and Mr. WALSH seconded, that the good wishes of the Society be sent to Professor LIVERSIDGE in London, and that gratification be expressed at his restoration to health.

Mr. MAIDEN exhibited three rare *Banksias* and two uncommon *Dryandras* from Western Australia.

ABSTRACT OF PROCEEDINGS, JUNE 1, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 1st, 1910.

H. D. WALSH, B.A.I., M.Inst.C.E., Vice-President, in the Chair.

Twenty-six members and seven visitors were present.

The minutes of the preceding meeting were read and confirmed.

A telegram was received from Prof. DAVID at Adelaide regretting that he would be unable to attend the meeting.

Mr. T. H. JOHNSTON and Dr. E. S. STOKES were appointed Scrutineers and Mr. HENRY DEANE deputed to preside at the Ballot Box.

The certificates of five candidates were read for the second time, and of two for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

DARNELL-SMITH, GEO. PERCY, B.Sc., F.I.C., F.C.S., Bureau of Microbiology, Macquarie-street.

FARRELL, JOHN, Assistant Teacher, Sydney Technical College; 55 Surrey-street, Darlinghurst.

SIMPSON, WILLIAM WALKER, Merchant, Leichhardt-street, Waverley.

WALKER, CHARLES, Metallurgical Chemist, etc.; "Kuranda," Waverley-street, Waverley.

WALKOM, ARTHUR BACHE, B. Sc., Junior Demonstrator in Geology, University of Sydney; "Newry," 32 Henson-street, Summer Hill.

Mr. MAIDEN announced that the LORD MAYOR had convened a meeting to be held in the Vestibule of the Town Hall, on Thursday the 16th instant at 3·30 p.m., at which members were invited to be present. The matter of the Commonwealth invitation to the British Association in 1913-4 would be discussed.

The Chairman announced that bound copies of the Society's Journal for 1909, could be had, by those members entitled to the same, on application to the Assistant Secretary.

Twenty-nine volumes, 182 parts, 14 reports, 12 pamphlets and 5 maps, total 242, received as donations since the previous meeting, were laid upon the table and acknowledged.

A letter was read from the Private Secretary, State Government House, acknowledging receipt of letter to the State Governor, covering one for H.M. The King.

THE FOLLOWING PAPERS WERE READ:

1. "Note on the Influence of Infantile Mortality on Birth-rate," by G. H. KNIBBS, F.S.S., F.R.A.S., etc., Commonwealth Statistician.

2. "The determination of Alkali in Arsenical Dip-fluids," by L. COHEN, Department of Agriculture. [Communicated by F. B. GUTHRIE, F.I.C., F.C.S.]
3. "Note on Mr. L. Hargrave's paper 'Lope de Vega,'" by Professor A. C. HADDON, D.Sc., was read by Mr. C. HEDLEY.
4. "On Australian Avian Entozoa," by T. HARVEY JOHNSTON, M.A., B.Sc., Assistant Government Microbiologist.
5. "The Great Weather Cycle," by T. W. KEELE, M. Inst. C.E.

EXHIBIT.

Mr. T. HARVEY JOHNSTON exhibited a series of entozoa comprising:—

Physaloptera sp. from the intestine of a sleeping lizard *Tiliqua scincoides* (Sydney); *Physaloptera sp.* from the duodenum of *Lygosoma tenue* (Millfield, N.S.W., collected by F. H. Taylor); *Physaloptera sp.* from the monitor *Varanus varius* (Sydney, Bathurst); *Echinorhynchus sp.* from the intestine of a brown snake *Diemenia textilis* (Millfield, N.S.W., collected by W. G. Hall); *Ichthyotaenia sp.* from the intestine of the black snake *Pseudechis porphyriacus* (Gosford, coll. L. Gallard; Richmond, C. T. Musson; Millfield, W. G. Hall; Sydney, T. H. J.; Gippsland, Victoria, A. S. Le Souef). He also showed a number of parasites identified by him from a collection made by Mr. A. S. Le Souef, now Curator of the Royal Zoological Gardens, Sydney, the greater part being obtained in Victoria, many of them having not been previously recorded as occurring in that State. It included the following:—*Dipylidium caninum* and *Ascaris canis*, from both the dog and cat (Victoria); *Taenia marginata*, from the dog (Vict); *Trichocephalus crenatus* from the caecum of a pig (Gippsland, Vict.); *Paramphistomum cervi* (syn. *Amphistomum conicum*) from the stomach of a cow (Gippsland); *Gastrodiscus polymastos*, Leuckt, (syn. *G. aegyptiacus*) (intestine), *Anoplocephala perfoliata* (intestine) and *Spiroptera microstoma* (stomach) from horses (Vict.), the first named being a very rare parasite in Australia, this being its first recorded occurrence; *Oestrus ovis* (larvae),

the sheep-bot (Vict.); *Filaria sp.* from subcutaneous tumours in the bridled nail-tailed wallaby *Onchogale frenata* (Vict.); and *Filaria sp.* from below the skin of Bennett's tree kangaroo *Dendrolagus bennettianus* (North Queensland). He also recorded the occurrence (though not common) of *Anoplocephala plicata* in horses in Victoria.

ABSTRACT OF PROCEEDINGS, JULY 6, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday, July 6th, 1910.

Prof. T. W. E. DAVID, B.A., F.R.S., President, in the Chair.

Thirty-five members and five visitors were present.

The minutes of the preceding meeting were read and confirmed.

Dr. C. ANDERSON and Mr. C. A. SÜSSMILCH were appointed Scrutineers and Mr. HENRY DEANE deputed to preside at the Ballot Box.

The certificates of two candidates were read for the second time.

The following candidates were balloted for and declared duly elected ordinary members of the Society, viz:—

WATT, FRANCIS LANGSTON, F.I.C., 10 Northcote Chambers, off 16½ Pitt-street.

WILLIAMS, Dr. J. M., D.D., F.R.G.S., F.E.S., "Duffryn," Parkstone Avenue, Parkstone, Dorset, England.

Nine volumes, 156 parts, 12 reports, 5 pamphlets and 1 map, total 183, received as Donations since the previous meeting were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "On the respective limits of Federal and State Legislation in regard to Companies," by A. DUCKWORTH, F.R.E.S. Remarks were made by Mr. CARMENT.
2. "Records of the earlier French Botanists, as regards Australian Botany," by J. H. MAIDEN, F.L.S. Remarks were made by Mr. CAMBAGE.
3. "Stone Rolls, in the Bulli Coal Seam of N. S. Wales," by W. G. WOOLNOUGH, D.Sc., F.G.S. Remarks were made by the President.
4. "Worm-nests in Australian Cattle due to *Filaria (Onchocerca) Gibsoni*, with notes on similar structure in Camels" by J. BURTON CLELAND, M.D., Ch.M., and T. HARVEY JOHNSTON, M.A., B.Sc.
5. "On the anatomy and possible mode of transmission of *Filaria (Onchocerca) Gibsoni*," by T. HARVEY JOHNSTON, M.A., B.Sc., and J. BURTON CLELAND, M.D., Ch.M.
6. "Palæontology of the Lower Shoalhaven River," by C. F. LASERON. [Communicated by R. T. BAKER, F.L.S.] In the absence of Mr. BAKER, the paper was read by Mr. HENRY G. SMITH, F.C.S. Remarks were made by Dr. WOOLNOUGH.

Owing to the lateness of the hour, the paper on "White Australia," by A. DUCKWORTH, F.R.E.S., was postponed to the next meeting.

EXHIBITS:

Various exhibits were shown and described by Mr. J. H. MAIDEN and Dr. WOOLNOUGH.

Mr. T. HARVEY JOHNSTON exhibited a series of entozoa (Cestodes) from New South Wales fishes :—

(1) *Phyllobothrium sp.* from the spiral valve of the fiddler, *Trygonorrhina fasciata*, Müll and Henle (Sydney); (2) *Phyllobothrium vagans*, Hasw., from spiral valve of the Port Jackson shark, *Heterodontus (Cestracion) philippi*, Bl. Schn. (Sydney); (3)

Phyllobothrium sp., (4) *Anthobothrium sp.*, (5) *Monorygma sp.* and (6) *Tetrarhynchus sp.*, form the spiral valve of the banded wobbegong, *Orectolobus ornatus*, De Vis (Sydney); (7) *Phyllobothrium sp.*, from the spiral valve of the ocellated wobbegong, *Orectolobus maculatus*, Bonnaterre (syn. *O. barbatus*, Gmèl.) Sydney; (8) *Phyllobothrium sp.* from the spiral valve of the commoh sting ray, *Trygonoptera testacea*, Müll and Henle (Sydney); (9) *Tetrarhynchus sp.* (immature) from the groper, *Achoerodus gouldii*, Rich.(Sydney); (10) *Tetrarhynchus sp.* from the muscles of the tailer, *Pomatomus saltatrix*, Linn. (Sydney and West Australia); (11) *Bothriocephalus sp.* from the freshwater eel *Anguilla reinhardtii*, Steind. (Prospect, Sydney).

ABSTRACT OF PROCEEDINGS, AUGUST 3, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 3rd, 1910.

Prof. DAVID, B.A., C.M.G., F.R.S., President, in the Chair.

Thirty-five members and two visitors were present, viz., Dr. J. V. DANES of Prague University, and J. ALLAN THOMPSON, B.A., Geologist to Capt. SCOTT'S British Antarctic Expedition, 1910.

The minutes of the preceding meeting were read and confirmed.

The President referred to the loss the Society has sustained through the death of Dr. WALTER SPENCER, one of our Vice-Presidents, and drew attention to the necessity of supporting the work of the British Science Guild in which Dr. SPENCER had taken so keen an interest, and of which he had been President up to the time of his death.

The certificate of one candidate was read for the first time.

The President made the following announcements:—

1. That 182 parts, 20 reports, 19 pamphlets and 2 maps, total 250, received as donations since the last meeting were laid upon the table and acknowledged.

2. That the third Popular Science Lecture of the Session would be delivered on Thursday, August 18th, on "The Mountains of N.S. Wales, their nature and origin" by Mr. C. A. SUSSMILCH.

THE FOLLOWING PAPERS WERE READ:

1. "On White Australia," by Mr. A. DUCKWORTH, F.R.E.S.

Remarks were made by Messrs. CARMENT, CLUNIES ROSS, JOSEPH PALMER, and Dr. CLELAND.

Mr. CARMENT and Dr. CLELAND proposed referring the discussion of the problem dealt with to a special committee such as the British Science Guild.

Mr. JOSEPH PALMER doubted the possibility of permanently excluding the coloured races in view of the increasing activity of Eastern races.

The President referred to a lecture recently delivered in Sydney by Dr. DANES (who was present at the meeting as a visitor) who showed that the Barkly Tableland was habitable by white people, and insisted on the necessity of keeping Australia white.

2. "The Haematozoa of Australian Batrachians" No. 1, by J. BURTON CLELAND, M.D., Ch.M., and T. HARVEY JOHNSTON, M.A., B.Sc. Read by Dr. CLELAND.

3. "An excursion to the Yosemite, or studies in the formation of Alpine Cirques, Steps, and Valley Treads," by E. C. ANDREWS, B.A. Read by Mr. SUSSMILCH.

Dr. J. V. DANES, Professor of Geology at the University of Prague, at the invitation of the President, referred to a discussion of this subject at the recent Geneva Congress where several theories were discussed, the general con-

census of opinion being he thought in favour of sub-glacial action as explaining the phenomena dealt with.

Mr. SUSSMILCH in replying; pointed out that though the arguments advanced by Mr. ANDREWS were drawn by him from the Yosemite Valley, they were not to be regarded as being of merely local significance, but were typical of what took place elsewhere.

The President read a letter received from Professor JOSEPH BURRELL of Yale University, in which he referred in highly complimentary terms to a previous paper of Mr. ANDREWS on "Corrasion by Gravity Streams," published in the last volume of the Royal Society of N. S. Wales, stating that "it has impressed us as one of the most important contributions to the science of erosion and resulting land forms." "It is a case where we have to go to the antipodes for knowledge."

4. "A note on the occurrence of Pentastomes in Australian Cattle," by T. HARVEY JOHNSTON, M.A., B.Sc., and J. BURTON CLELAND, M.D., M.Ch. Read by Mr. JOHNSTON.

5. "On the condition of the atmosphere during the recent proximity of Halley's Comet," by H. G. A. HARDINGE, Technical College. (Communicated by W. J. CLUNIES ROSS, B.Sc.)

Remarks were made by Prof. FAWSITT.

EXHIBITS.

1. His Honor JUDGE DOCKER exhibited four photographic views showing the panorama from the summit of the peak of Mount Warning, Tweed River; also a collection of stereoscopic slides of Mount Warning from different points of view.

2. Mr. R. T. BAKER showed specimens of artificial silk prepared from wood-pulp.

3. Mr. T. H. JOHNSTON exhibited a series of entozoa taken by him from reptiles collected by Dr. D'OMBRAIN in the Sydney district.

(1) *Physaloptera sp.*, and (2) *Ascaris sp.*, from the intestine of the common whip-snake *Diemenia psammophis*, Schl.; (3) *Ichthyotaenia sp.*, (a tapeworm from the duodenum resembling that found in local black snakes *Pseudechus porphyriacus*, Shaw), (4) *Trichosomum sp.* (a very delicate nematode from the intestine), (5) *Apoblema sp.* (a Distomid fluke with a small but well-marked caudal appendage, from the oesophagus), and (6) *Porocephalus sp.* (a pentastome from the lungs), all four species being taken from one copper-headed snake, *Denisonia superba*, Günther; (7) *Physaloptera sp.* from the intestine of a slow-worm *Lialis burtonii*, Gray. He also showed some entozoa collected for him by Mr. L. GALLARD in the Gosford district (N. S. Wales). (8) *Gigantorhynchus sp. (G. semoni*, Linst.?), from the long-nosed bandicoot *Perameles nasuta*, Geoffr.; (9) *Gigantorhynchus sp.* from the brush tailed "rat" *Phascologale penicillata;* (10) *Filaria sp.*, from the peritoneum of the common black opossum *Trichosurus caninus*.

4. Mr. GUTHRIE showed a cob of black maize grown by a farmer in the Coramba district. It is asserted that the variety is not attacked by weevil.

ABSTRACT OF PROCEEDINGS, SEPTEMBER 7, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 7th, 1910.

H. DEANE, M.A., M. Inst. C.E., Vice-President, in the Chair.

Twenty-five members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Mr. Lawrence Hargrave and Dr. George Harker were appointed Scrutineers and Mr. R. H. Cambage deputed to preside at the Ballot Box.

The certificates of three candidates were read for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Becke, Louis, F.R.G.S., 15 Clarence Street.
Watson, James Frederick, M.B., Ch.M., Australian Club.
Wearne, Richard Arthur, Ipswich, Queensland.

Eleven volumes, 177 parts, 14 reports, 7 pamphlets, 2 maps, total 211, received as Donations since the previous meeting were laid upon the table and acknowledged.

CORRESPONDENCE.

Letters from Prof. Liversidge, LL.D., F.R.S., London:—

(1) Thanking the retiring President and members for their congratulations on his recovered health.

(2) Stating that he would have very much pleasure in representing the Royal Society of New South Wales at the Convention for the International Catalogue of Scientific Literature at the Royal Society's House on July 12th and 13th.

(3) Stating that he had duly attended the meetings of the Convention, and enclosing copy of the Acta.

THE FOLLOWING PAPERS WERE READ:

1. "On the interpretation of the Precipitin Reaction," by Prof. D. A. Welsh, M.A., M.D., and Dr. H. G. Chapman, B.Sc. Remarks were made by Dr. Chapman.

2. "Studies in Statistical Representation, on the nature and computation of the curve $y = Ax^m e^{nx^p}$ by G. H. Knibbs, F.S.S., F.R.A.S., Commonwealth Statistician.

3. "The anatomy of the head of the Green Turtle (*Chelone midas*) Part I, The Skull," by H. LEIGHTON KESTEVEN, B.Sc., Lecturer in Physiology, Technical College, Sydney. (Communicated by C. HEDLEY, F.L.S.)

EXHIBIT.

A new apparatus for the administration of ether, (open method) by Mr. C. E. HODGSON.

ABSTRACT OF PROCEEDINGS, OCTOBER 5, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday, October 5th, 1910.

Prof. DAVID, B.A., C.M.G., F.R.S., President, in the Chair.

Twenty-six members and one visitor were present.

Mr. A. B. WALKOM enrolled his name and was introduced.

One visitor, Dr. HAMBLYN HARRIS, was introduced by Mr. C. HEDLEY.

The minutes of the preceding meeting were read and confirmed.

Messrs. J. E. CARNE and G. H. HALLIGAN were appointed Scrutineers and Mr. R. H. CAMBAGE deputed to preside at the Ballot Box.

The certificates of three candidates were read for the second time, and one for the first time.

The following candidates were balloted for and declared duly elected ordinary members of the Society, viz:—

BRADLEY, CLEMENT HENRY BURTON, M.B., Ch.M., D.P.H., Government Bureau of Microbiology.

POTTS, HENRY WILLIAM, F.L.S., F.C.S., Principal of the Hawkesbury Agricultural College.

WALKER, Major HAROLD HUTCHISON, "Percy House," Snail's Bay, Balmain.

Nineteen volumes, 187 parts, 15 reports, and 7 pamphlets total 228, received as Donations since the previous meeting were laid upon the table, and acknowledged.

It was proposed by Mr. C. HEDLEY, and seconded by Mr. R. H. CAMBAGE, that in order to stimulate public interest in the proposed Antarctic Expedition, which includes among its members a highly scientific staff, this Society considers it desirable that the President should try and induce the leader of the Expedition, Captain R. F. SCOTT, R.N., C.V.O., to lecture in Sydney, prior to his departure from Australia. Carried unanimously.

THE FOLLOWING PAPERS WERE READ:

1. Remarks upon Mr. T. W. KEELE'S paper "The Great Weather Cycle," were made by the following gentlemen:—Messrs. J. W. SMAIL, H. G. MCKINNEY, J. E. CARNE, J. BARLING, and J. H. MAIDEN. The President moved that a vote of thanks be given to Mr. KEELE for his valuable paper, to which Mr. KEELE duly replied.

2. "On some Rock Engravings of the Aborigines of New South Wales," by R. H. MATHEWS, L.S.

3. "The Haematozoa of Australian Fish, No. 1," by T. HARVEY JOHNSTON, M.A., B.Sc., and J. BURTON CLELAND, M.D., Ch.M.

4. "Notes on the suitability of tropical Australia for the races," by Dr. T. V. DANES. (Communicated and read by Prof. T. W. E. DAVID.)

ABSTRACT OF PROCEEDINGS, NOVEMBER 2, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 2nd, 1910.

Prof. DAVID, B.A., C.M.G., F.R.S., President, in the Chair.

Thirty-three members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Dr. C. ANDERSON and Mr. W. S. DUN were appointed Scrutineers and Dr. W. G. WOOLNOUGH deputed to preside at the Ballot Box.

The certificate of one candidate was read for the second time.

The following candidate was balloted for and declared a duly elected ordinary member of the Society, viz.:—

ESTENS, JOHN LOCKE, 55 Flinders-street, Sydney.

It was announced that the lecture by Mr. R. F. IRVINE, M.A., on "The Social View of Capital," that should have been given on the 20th of October, would be delivered on Tuesday, November 8th and that a second lecture on the same subject would be given on Friday, November 11th.

Twenty-five volumes, 136 parts, 13 reports, 6 pamphlets and 2 maps, total 182, received as donations since the last meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "The Geographical Unity of Eastern Australia," by E. C. ANDREWS, B.A. The paper was read by Mr. C. A. SÜSSMILCH, the following gentlemen taking part in the discussion, viz., Messrs. W. S. DUN, J. E. CARNE, Dr. WOOLNOUGH and Prof. DAVID.

2. "The Volcanic Necks of Hornsby and Dundas near Sydney," by W. S. BENSON, B.Sc. Remarks were made by Dr. WOOLNOUGH, C. A. SÜSSMILCH, and Prof. DAVID.

3. "Note on the occurrence of Eurydesma in the Upper Marine (Permo-Carboniferous) of New South Wales," by W. G. WOOLNOUGH, D.Sc., F.G.S. Remarks were made by Prof. DAVID.
4. "Note on the Geology of King Island," by F. DEBENHAM, B.A. (Communicated and read by Dr. WOOLNOUGH.)
5. "Azurite Crystals from Broken Hill," by F. COHEN, B.A., B.Sc. (Communicated and read by Dr. WOOLNOUGH.) Remarks were made by Dr. ANDERSON.

EXHIBITS.

Dr. WOOLNOUGH exhibited Eurydesma from near Singleton

Mr. W. W. SIMPSON, pilbarite from North Australia.

Mr. ESDAILE, Ott's compensating planimeter.

Mr. BENSON, photographs illustrating his paper.

ABSTRACT OF PROCEEDINGS, DECEMBER 7, 1910.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 7th, 1910.

Prof. T. W. E. DAVID, B.A., F.R.S., C.M.G., President, in the Chair.

Thirty-five members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

The certificate of one candidate was read for the first time.

Twenty volumes, 129 parts, 11 reports, 31 pamphlets, 3 maps, total 194 were laid upon the table and acknowledged.

A letter from Mrs. E. MACDONELL acknowledging the vote of sympathy in regard to the death of her husband was read.

THE FOLLOWING PAPERS WERE READ:

1. "Experiments with Silicate of Soda and observations thereon," by W. J. CLUNIES ROSS, B.Sc, F.G.S. The author showed a large number of exhibits in illustration of his paper. The following gentlemen took part in the discussion:—Professor FAWSITT, Dr. GREIG-SMITH, Dr. HARKER, Dr. COOKSEY, and Mr. GUTHRIE.

2. "The Melaleucas and their essential Oils," by R. T. BAKER, F.L.S. and H. G. SMITH, F.C.S. Read by Mr. BAKER as regards the Botanical, and Mr. SMITH as regards the Chemical portion, a large number of lantern slides illustrating plant sections being shown. Mr. J. H. MAIDEN, offered some remarks.

3. "Notes on some recently discovered plants from the Sydney Harbour Colliery," by W. S. DUN, F.G.S.

4. "Sand Blast Tests of New South Wales Timbers," by Prof. WARREN, M. Inst. C.E. Mr. DEANE and Mr. MAIDEN took part in the discussion.

The President wished members the good wishes for the approaching Christmas season, and members wished the President a pleasant voyage and safe return from his impending brief visit to England.

EXHIBITS:

Mr. BAKER exhibited photographs and samples of South Australian marine plants, *Posidonia australis*, the sheathing bases of the leaves of which produce a valuable fibre.

Judge DOCKER exhibited views and photographs of scenery on the ascent of Mount Warning, Tweed River.

The following donations were laid upon the table and acknowledged:—

TRANSACTIONS, JOURNALS, REPORTS, &c.

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GEOLOGICAL SECTION.

PROCEEDINGS OF THE GEOLOGICAL SECTION.

(IN ABSTRACT.)

General Monthly Meeting 13th April, 1910.

Mr. J. E. Carne in the Chair.

Nine members and two visitors were present.

Mr. J. E. Carne was re-elected chairman, and Mr. C. A. Sussmilch re-elected Secretary for the current year. A discussion took place on Mr. E. C. Andrews' paper on "Corrasion by Gravity Streams and its application to the Flood Hypothesis," read at the meeting of the Society on November 3rd, 1909. Prof. David, Messrs. Cotton, Carne and Sussmilch spoke on the discussion.

General Monthly Meeting, 11th May, 1910.

Mr. J. E. Carne in the Chair.

Eight members and two visitors were present.

Dr. C. Anderson exhibited specimens of natrolite from Ard Glen, N.S.W., and stichtite from Tasmania.

Mr. W. S. Dun exhibited the following fossils:—(1) Specimen of *Eurydesma hobartense* from Porter's Bay, Hobart. This is apparently the type of Frech's *Leiomyalina antarctica.* The same species occurs in the Upper Marine stage of the Hunter River coalfield, and is characterised by the lesser convexity of the shell and corresponding modification of the hinge structures. (2) Specimens of young individuals of *Eurydesma cordata* from the Lower Marine of Beaconsfield, where they are associated with a *Strophalosia* apparently identical with a species very common in the Upper Marine shales of Branxton. (3) Speci-

mens of Upper Silurian Gastropoda, Pelecypoda, and Brachiopoda from Zeehan.

A discussion took place on Mr. C. A. SUSSMILCH's paper on "The Physiography of the Southern Tableland of New South Wales," read at the November meeting of the Society.

General Monthly Meeting, 8th June, 1910.

Mr. R. H. CAMBAGE in the Chair.

Ten members present.

Mr. STRATHAM exhibited an alleged glaciated boulder from Coff's Harbour, N.S. Wales, and some pot-hole pebbles from near Parramatta.

Dr. C. ANDERSON exhibited specimens of precious opal, pseudomorphous after some unknown fibrous mineral, from Lightning Ridge near Walgett.

Mr. W. N. BENSON exhibited a stereogram of the Mount Lofty Ranges, South Australia, and a sketch map of the Barrier District, N.S.W., showing the existence of a probable fault scarp bounding the western side of this region.

A discussion then took place on the geological range of *Lepidodendron australe* in Australia. The discussion brought out the fact that this fossil plant occurs in undoubted Upper Devonian strata at many localities, but that no absolutely certain cases are known of its occurrence in strata of younger age.

General Monthly Meeting 13th July, 1910.

Mr. J. E. CARNE in the Chair.

Thirteen members and four visitors present.

Mr. J. E. CARNE exhibited a specimen of wolfram showing zoned structure, from the Butler Tin Lode, New England.

Dr. C. ANDERSON exhibited specimens of monazite from near Trundle, N.S.W.

Mr. ALLEN THOMPSON exhibited a Glaucophane Rock from the Kimberly District, West Australia.

Mr. W. N. BENSON exhibited a radiolarian chert from the Municipal Quarry at Rockhampton, Queensland.

Mr. W. SIMPSON exhibited a specimen of amblygonite from Coolgardie, West Australia.

Mr. C. A. SUSSMILCH exhibited a specimen of *Alethropteris* from the Upper Coal Measures in the Balmain Colliery, Sydney. Mr. W. S. DUN pointed out that it was closely related to Triassic species.

A discussion was then held on Mr. C. HEDLEY'S recent Presidential Address to the Linnean Society of N.S. Wales* in which Messrs. W. S. DUN, T. G. TAYLOR, A. THOMPSON, W. N. BENSON, and C. A. SUSSMILCH took part. The discussion was then adjourned to the following meeting.

General Monthly Meeting, 10th August, 1910.

Mr. J. E. CARNE in the Chair.

Nine members present.

Dr. C. ANDERSON exhibited specimens of orthoclase from Bolivia and Oban, N.S.W.

Mr. W. S. DUN exhibited examples of Permo-Carboniferous fossils collected by Mr. J. E. CARNE in New England. establishing the age of a great extent of palæozoic rocks: (1) Swamp Oak Creek, Ph. Arvid, Co. Gough, *Protoretepora*, *Fenestella fossula*, *Stenopora* cf. *gimpiensis*, *Spirifera* cf. *tasmaniensis*, *Chonetes*, *Productus (?)*, *Conularia lævigata*, *Ptychomphalina* and *Loxonema (?)*. (2) Rocky Creek, Ph. Bowman, Co. Arrawatta:—*Fenestella* cf. *fossula*, *Hemitrypha hexangula (?)*, *Productus brachythærus*, *Martiniopsis subradiata*, *M. oviformis*, *Spirifera duo-*

decimcostata, *S.* cf. *vespertilio*, *S.* cf. *Clarkei*, *Dislasma*, *Aviculopecten* cf. *squamuliferus*, *Deltopecten subquinquelineatus*, *Chœnomya (?)*. These specimens will be referred to in the forthcoming "Mineral Resources—Tin," by Mr. J. E. Carne.

Mr. W. S. Dun also exhibited a specimen of *Fenestella fossula* from near Mount Baring, at the head of the Logan River, near the New South Wales-Queensland Border, demonstrating the Permo-Carboniferous age of the strata. The specimen was forwarded by Mr. A. Wearne of Ipswich.

Mr. W. N. Benson exhibited a collection of vesuvianite and garnet-bearing limestones altered by intrusion of granite (collected by Mr. D. A. Porter, near Tamworth). A green-garnet vesuvianite rock from the Severn River near Ballandean, Queensland; a bastite rock from Bowling Alley Point, showing poikilitic inclusion of serpentinised olivine crystals in the bastate plates; a shonkinitic nephelinite, and melilite basalt from Shannon Tier, Tasmania, presented by Mr. W. H. Twelvetrees; two microphotographs of pleonaste bearing gabbroid rocks included in the basalt of Dundas; one of these showed a remarkable granophyric intergrowth of pleonaste and pyroxene, and as far as can be seen at present, appears to be a unique rock type. He suggested that the spinel may be formed from the syntectic magma produced by the re-solution of plagioclase in a peridotitic magma, the crystallisation in such a melt startiug in fibres perpendicular to the boundaries of the solution cavities. The peculiar shape of these appears to negative the suggestion that the intergrowth is a eutectic of the latest formed minerals.

The discussion on Mr. C. Hedley's Presidential Address was resumed, Messrs. G. H. Halligan, J. E. Carne, C. A. Sussmilch, and Drs. C. Anderson and H. I. Jensen taking part. Mr. C. Hedley replied at some length.

General Monthly Meeting, 14th September, 1910.

Mr. R. H. CAMBAGE in the Chair.

Nine members and two visitors present.

Mr. A. THOMPSON exhibited a supposed new telluride from Kalgoorlie, probably a copper telluride containing gold.

Mr. L. COTTON exhibited crystallised wolfram with fluorite and smaltite from the Bismuth Cos. Mine, Torrington, also native bismuth and adularia from Torrington.

Mr. C. HEDLEY gave an abstract of Dr. WOOD JONES' recent book on Coral Atolls.

Mr. J. CLUNIES ROSS exhibited and gave extracts from a manuscript criticism written by JOHN CLUNIES ROSS of Cocos Island in 1850, on DARWIN'S book on Coral Reefs.

General Monthly Meeting, 12th October, 1910.

Mr. R. H. CAMBAGE in the Chair.

Five members and two visitors present.

The evening was devoted to a discussion on the probable cause of the local folding which occurs in the current-bedded sandstones of the Sydney District. No definite conclusions was arrived at.

General Monthly Meeting, 9th November, 1910

Mr. J. E. CARNE in the Chair.

Twelve members and one visitor present.

The Secretary, in the absence of the author, read Mr. E. C. ANDREWS' paper on the Geographical Unity of Eastern Australia, a brief abstract of which had been given at the previous monthly meeting of the Society. Prof. T. W. E. DAVID, opened the discussion which was then adjourned until such time as printed copies of the paper should be available and Mr. ANDREWS be present.

General Monthly Meeting, 14th December, 1910.

Mr. J. E. CARNE in the Chair.

Nine members present,

Mr. W. N. BENSON exhibited specimens of bastite, gabbro, and serpentine from Bowling Alley Point.

Mr. J. E. CARNE exhibited specimens of green tourmaline from Mount Bishop, Tasmania.

Father PIGOT made some remarks regarding recent earthquakes which had taken place under the bed of the Pacific Ocean during the current year.

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